UNIT-4 Biological basis of behavior

DIWAKAR EDUCATION HUB

SHOUT
SHARE
IT

What is Sensory systems: General and specific sensations, receptors and processes Neurons: Structure, functions, types, neural impulse, synaptic transmission. Neurotransmitters?

Sensory systems: General and specific sensations, receptors and processes Neurons: Structure, functions, types, neural impulse, synaptic transmission. Neurotransmitters

an In more advanced animals, the senses are constantly at work, making the animal aware of stimuli, such as light or sound or the presence of a chemical substance in the external environment, while monitoring information about the organism's internal environment. All bilaterally symmetric animals have a sensory system.

The development of any species ' sensory system has been driven by natural selection; thus, sensory systems differ among species according to the demands of their environments. For example, the shark, unlike most fish predators, is electrosensitive (i.e., sensitive to electrical fields produced by other animals in its environment). While it is helpful to this underwater predator, electrosensitivity is a sense not found in most land animals.

Senses provide information about the body and its environment. Humans have five special senses: olfaction (smell), gustation (taste), equilibrium (balance and body position), vision, and hearing. Additionally, we possess general senses, also called

somatosensation, which respond to stimuli like temperature, pain, pressure, and vibration. Vestibular sensation, which is an organism's sense of spatial orientation and balance, proprioception (position of bones, joints, and muscles), and the sense of limb position that is used to track kinesthesia (limb movement) are part of somatosensation.

Although the sensory systems associated with these senses are very different, all share a common function: to convert a stimulus (light, sound, or the position of the body) into an electrical signal in the nervous system. This process is called sensory transduction.

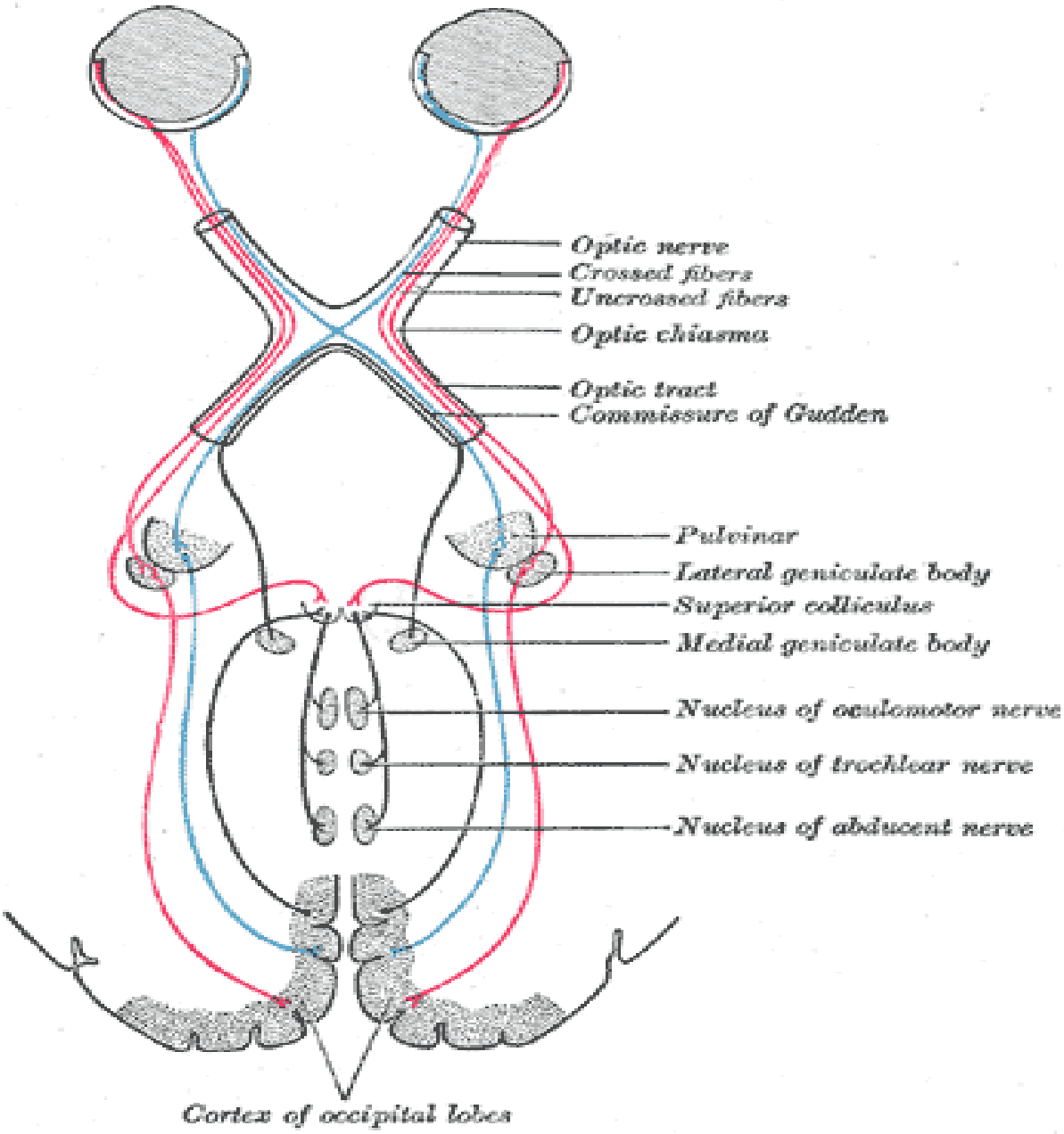
There are two broad types of cellular systems that perform sensory transduction. In one, a neuron works with a sensory receptor, a cell, or cell process that is specialized to engage with and detect a specific stimulus. Stimulation of the sensory receptor activates the associated afferent neuron, which carries information about the stimulus to the central nervous system. In the second type of sensory transduction, a sensory nerve ending responds to a stimulus in the internal or external environment; this neuron constitutes the sensory receptor.

Free nerve endings can be stimulated by several different stimuli, thus showing little receptor specificity. For example, pain receptors in your gums and teeth may be stimulated by temperature changes, chemical stimulation, or pressure.

Reception

The first step in sensation is reception: the activation of sensory receptors by stimuli such as mechanical stimuli (being bent or squished, for example), chemicals, or temperature. The receptor can then respond to the stimuli. The region in space in which a given sensory receptor can respond to a stimulus, be it far away or

in contact with the body, is that receptor's receptive field. Think for a moment about the differences in receptive fields for the different senses. For the sense of touch, a stimulus must come into contact with body. For the sense of hearing, a stimulus can be a moderate distance away. For vision, a stimulus can be very far away; for example, the visual system perceives light from stars at enormous distances.



Visual sensory System:

This scheme shows the flow of information from the eyes to the central connections of the optic nerves and optic tracts, to the visual cortex. Area V1 is the region of the brain which is engaged in vision.

Key Points

- Sensory signals are converted to electrical signals via depolarization of sensory neuron membranes upon stimulus of the receptor, which causes opening of gated ion channels that cause the membrane potential to reach its threshold.
- The receptor potentials are classified as graded potentials; the magnitude of these potentials is dependent on the strength of the stimulus.
- The sensory system shows receptor specificity; although stimuli can be combined in processing regions of the brain, a specific receptor will only be activated by its specific stimulus.
- The brain contains specific processing regions (such as the somatosensory, visual, and auditory regions) that are dedicated to processing the information which has previously passed through the thalamus, the 'clearinghouse and relay station' for both sensory and motor signals.
- The four major components of encoding and transmitting sensory information include: the type of stimulus, the stimulus location within the receptive field, the duration, and the intensity of the stimulus.

Key Terms

- **membrane potential**: the difference in electrical potential across the enclosing membrane of a cell

- **action potential**: a short term change in the electrical potential that travels along a cell
- **transduction**: the translation of a sensory signal in the sensory system to an electrical signal in the nervous system

Transduction

The most fundamental function of a sensory system is the translation of a sensory signal to an electrical signal in the nervous system. This takes place at the sensory receptor. The change in electrical potential that is produced is called the receptor potential. How is sensory input, such as pressure on the skin, changed to a receptor potential? As an example, a type of receptor called a mechanoreceptor possesses specialized membranes that respond to pressure. Disturbance of these dendrites by compressing them or bending them opens gated ion channels in the plasma membrane of the sensory neuron, changing its electrical potential. In the nervous system, a positive change of a neuron's electrical potential (also called the membrane potential), depolarizes the neuron. Receptor potentials are graded potentials: the magnitude of these graded (receptor) potentials varies with the strength of the stimulus. If the magnitude of depolarization is sufficient (that is, if membrane potential reaches a threshold), the neuron will fire an action potential. In most cases, the correct stimulus impinging on a sensory receptor will drive membrane potential in a positive direction, although for some receptors, such as those in the visual system, this is not always the case.

Sensory receptors for the various senses work differently from each other. They are specialized according to the type of stimulus they sense; thus, they have receptor specificity. For example, touch receptors, light receptors, and sound receptors are each activated

by different stimuli. Touch receptors are not sensitive to light or sound; they are sensitive only to touch or pressure. However, stimuli may be combined at higher levels in the brain, as happens with olfaction, contributing to our sense of taste.

Encoding and Transmission of Sensory Information

Four aspects of sensory information are encoded by sensory systems: the type of stimulus, the location of the stimulus in the receptive field, the duration of the stimulus, and the relative intensity of the stimulus. Thus, action potentials transmitted over a sensory receptor's afferent axons encode one type of stimulus. This segregation of the senses is preserved in other sensory circuits. For example, auditory receptors transmit signals over their own dedicated system. The electrical activity in the axons of the auditory receptors will be interpreted by the brain as an auditory stimulus: a sound.

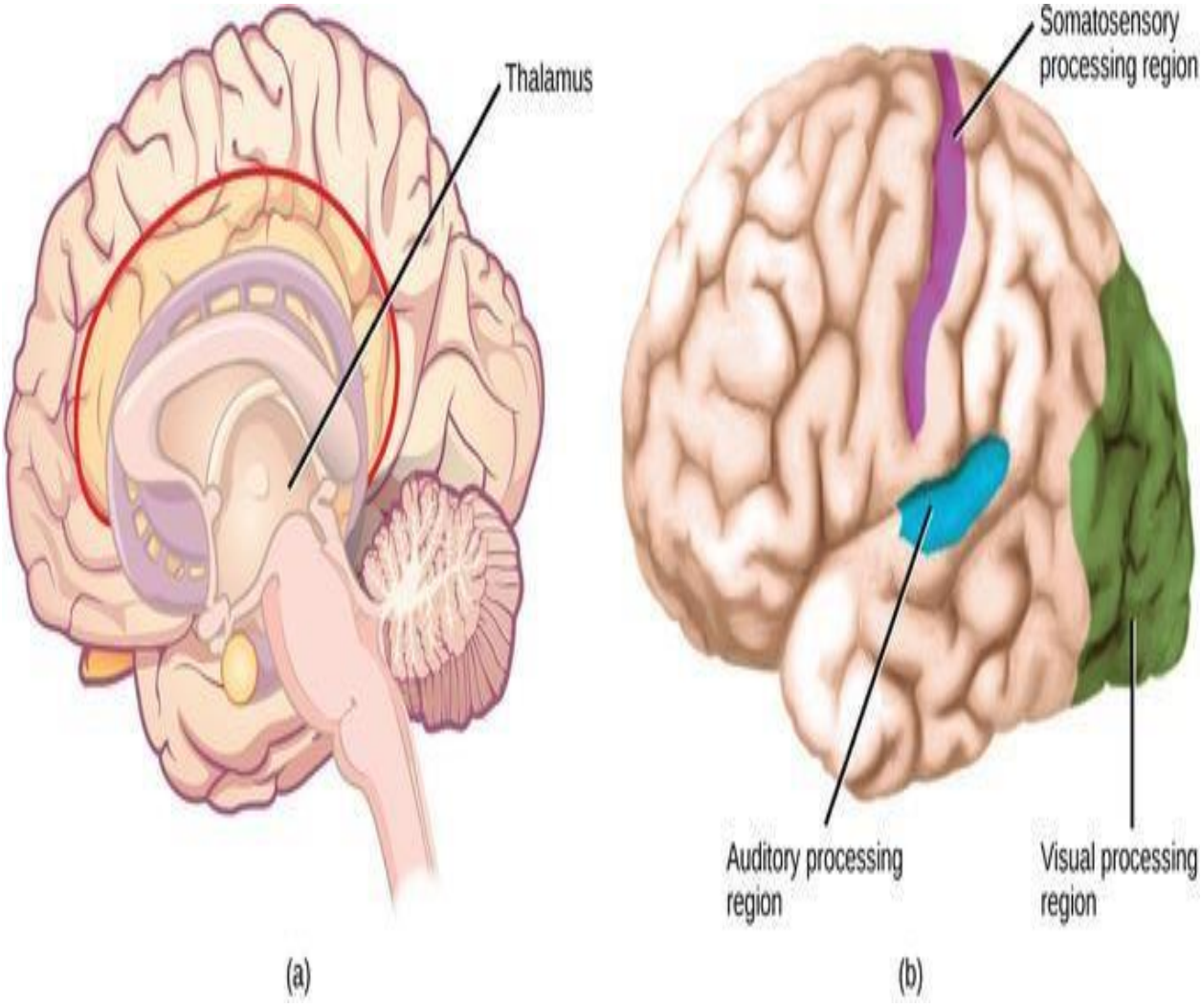
The intensity of a stimulus is often encoded in the rate of action potentials produced by the sensory receptor. Thus, an intense stimulus will produce a more rapid train of action potentials. Reducing the stimulus will likewise slow the rate of production of action potentials. A second way in which intensity is encoded is by the number of receptors activated. An intense stimulus might initiate action potentials in a large number of adjacent receptors, while a less intense stimulus might stimulate fewer receptors. Integration of sensory information begins as soon as the information is received in the central nervous system.

Perception

Perception is an individual's interpretation of a sensation. Although perception relies on the activation of sensory receptors, perception happens, not at the level of the sensory receptor, but at the brain

level. The brain distinguishes sensory stimuli through a sensory pathway: action potentials from sensory receptors travel along neurons that are dedicated to a particular stimulus.

All sensory signals, except those from the olfactory system, are transmitted though the central nervous system: they are routed to the thalamus and to the appropriate region of the cortex. The thalamus is a structure in the forebrain that serves as a clearinghouse and relay station for sensory (as well as motor) signals. When the sensory signal exits the thalamus, it is conducted to the specific area of the cortex dedicated to processing that particular sense.



Function of senses

• 1. Detection of sensations allow the human body to be aware of changes (or stimuli) that occur in the environment or inside the body.

• 2. These senses permit the central nervous system to produce reactions for the stimuli and maintain body homeostasis.

• 3. Somatic senses ("soma" means body) detect touch, pain pressure, temperature, and tension on the skin and in internal organs.

• 4. Special senses detect the sensations of taste, smell, hearing, equilibrium, and sight, only in special sense organs in the head region (a phenomenon known as “cephalization").

• 5. All senses are detected by sensory receptors, and after integration and processing being dong done in the central nervous system, motor nerves produce a response.

Somatic Senses

1. sensory receptors in the skin, muscles, joints, and visceral organs detect external and internal stimuli of the body.

2. Three types of somatic senses:

a) Exteroceptive senses detect changes that occur at body surface, such as touch, pressure and temperature.

b) Proprioceptive senses detect changes that occur in muscles, tendons, ligaments and joint tissues.

c) Visceroceptive senses detect changes that occur in internal organs.

Special Senses

• 1. The senses of taste and smell (detected by chemoreceptors), hearing and equilibrium (detected by mecanoreceptors), and vision (detected by photoreceptors) are the five special senses.

• 2. Require specialized sensory receptors within large, complex sensory organs in the head region

Sense of Smell

• a) olfactory receptors located in "olfactory organs " are specialized chemoreceptors in the nasal cavity.

• b) olfactory receptors are bipolar neurons surrounded by ciliated columnar cells. These sensory cells, after being stimulated by olfactory sensations, send nerve impulses along the olfactory (cranial nerve I) to the cerebrum.

• c) gases in the air entering the nasal cavity are dissolved by nasal mucus (secreted by goblet cells in the columnar epithelium), and the resulting solution stimulates various olfactory receptors.

Sense of Taste

• a) about 10,000 taste buds occur in the oral cavity, mostly on the tongue. Each taste bud contains 40-60 taste receptors. These sensory cells, are stimulated by taste sensations.

• b) chemical substances from the food or beverage enter the mouth and are dissolved in the saliva (secreted by salivary glands and mucous membrane of oral cavity).

• c) dissolved chemical substances stimulate various taste buds in different regions of the tongue, and combinations of taste sensations produce hundreds of different taste senses.

Sense of Vision

a) Accessory structures of the eye are those that are not directly related the sense of vision, but facilitate the physiology of the eyeballs.

• Eyebrows – to shade the eyes from sunlight and to prevent perspiration from reaching the eyes.

• Eyelids- to protect the eyes from foreign objects (e.g. dust particles) ,and to prevent desiccation (drying) of the eyes by lubricating fluid.

• Conjunctiva- a mucous membrane on the inner lining of eyelids, which produces lubricating and cleansing fluid for the surface of eye.

• Lacrimal gland- exocrine gland that secretes a dilute saline solution called tears for moistening the eyes. [Tears contain mucus, antibodies ,and antibacterial enzymes that protect the eye from infections. Emotional tears also contain enzymes that seem to help reduce stress levels].

Sense of Equilibrium

a) detected by mechanoreceptors in the semicircular canals to help maintain body posture and body stability.

b) nerve impulses generated by the receptors in semicircular canals are transmitted by the vestibular nerve to Nerve VIII, and the signals will be processed by the brain.

Sensory Modalities

Ask anyone what the senses are, and they are likely to list the five major senses—taste, smell, touch, hearing, and sight. However,

these are not all of the senses. The most obvious omission from this list is balance. Also, what is referred to simply as touch can be further subdivided into pressure, vibration, stretch, and hair-follicle position, on the basis of the type of mechanoreceptors that perceive these touch sensations. Other overlooked senses include temperature perception by thermoreceptors and pain perception by nociceptors. Within the realm of physiology, senses can be classified as either general or specific. A **general sense** is one that is distributed throughout the body and has receptor cells within the structures of other organs. Mechanoreceptors in the skin, muscles, or the walls of blood vessels are examples of this type. General senses often contribute to the sense of touch, as described above, or to **proprioception** (body movement) and **kinesthesia** (body movement), or to a **visceral sense**, which is most important to autonomic functions. A **special sense** is one that has a specific organ devoted to it, namely the eye, inner ear, tongue, or nose. Each of the senses is referred to as a **sensory modality**. Modality refers to the way that information is encoded, which is similar to the idea of transduction.

Sensory Receptors

- **Structural Receptor Types**
- **Functional Receptor Types**

A major role of sensory receptors is to help us learn about the environment around us, or about the state of our internal environment. Stimuli from varying sources, and of different types, are received and changed into the electrochemical signals of the nervous system. This occurs when a stimulus changes the cell membrane potential of a sensory neuron. The stimulus causes the sensory cell to produce an action potential that is relayed into the

central nervous system (CNS), where it is integrated with other sensory information—or sometimes higher cognitive functions—to become a conscious perception of that stimulus. The central integration may then lead to a motor response. Describing sensory function with the term sensation or perception is a deliberate distinction. **Sensation** is the activation of sensory receptor cells at the level of the stimulus. **Perception** is the central processing of sensory stimuli into a meaningful pattern. Perception is dependent on sensation, but not all sensations are perceived. Receptors are the cells or structures that detect sensations.

Sensory Receptors

Stimuli in the environment activate specialized receptor cells in the peripheral nervous system. Different types of stimuli are sensed by different types of receptor cells. Receptor cells can be classified into types on the basis of three different criteria: cell type, position, and function. Receptors can be classified structurally on the basis of cell type and their position in relation to stimuli they sense. They can also be classified functionally on the basis of the **transduction** of stimuli, or how the mechanical stimulus, light, or chemical changed the cell membrane potential.

Structural Receptor Types

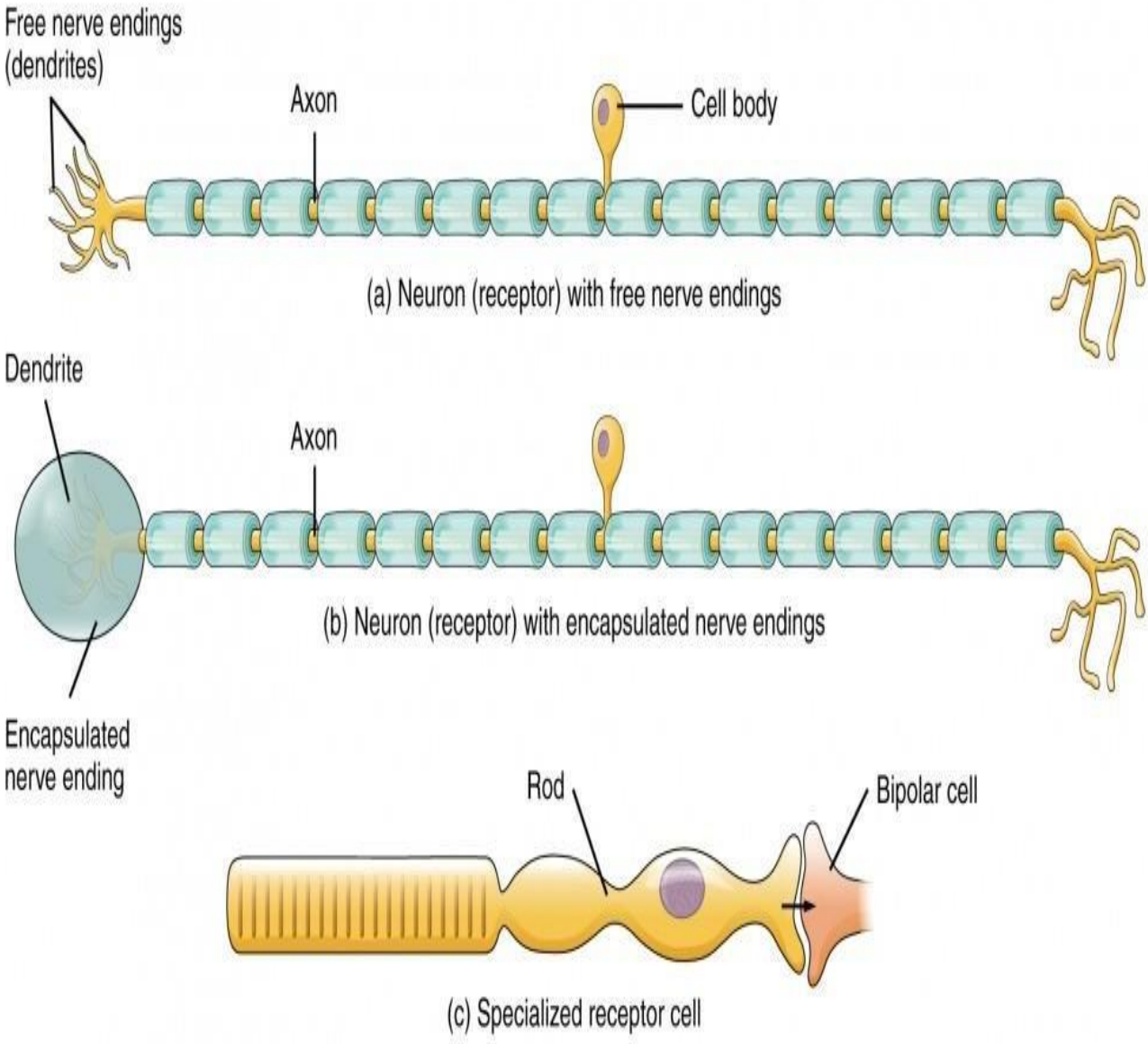
The cells that interpret information about the environment can be either

(1) a neuron that has a **free nerve ending**, with dendrites embedded in tissue that would receive a sensation;

(2) a neuron that has an **encapsulated ending** in which the sensory nerve endings are encapsulated in connective tissue that enhances their sensitivity; or

(3) a specialized **receptor cell**, which has distinct structural components that interpret a specific type of stimulus (Figure 8.30). The pain and temperature receptors in the dermis of the skin are examples of neurons that have free nerve endings. Also located in the dermis of the skin are lamellated corpuscles, neurons with encapsulated nerve endings that respond to pressure and touch.

The cells in the retina that respond to light stimuli are an example of a specialized receptor, a **photoreceptor**.



Receptor cell types can be classified on the basis of their structure. Sensory neurons can have either

(a) free nerve endings or

(b) encapsulated endings. Photoreceptors in the eyes, such as rod cells, are examples of

(c) specialized receptor cells. These cells release neurotransmitters onto a bipolar cell, which then synapses with the optic nerve neurons.

Another way that receptors can be classified is based on their location relative to the stimuli. An **exteroceptor** is a receptor that is located near a stimulus in the external environment, such as the receptors that are located in the skin. An **interoceptor** is one that interprets stimuli from internal organs and tissues, such as the receptors that sense the increase in blood pressure in the aorta or carotid sinus. Finally, a **proprioceptor** is a receptor located near a moving part of the body, such as a muscle, that interprets the positions of the tissues as they move.

Functional Receptor Types

A third classification of receptors is by the stimulus that is used to initiation the process of transduction. Chemical stimuli can be interpreted by a **chemoreceptor** that interprets chemical stimuli, such as an object's taste or smell. **Osmoreceptors** respond to solute concentrations of body fluids. Additionally, pain is primarily a chemical sense that interprets the presence of chemicals from tissue damage, or similar intense stimuli, through a **nociceptor**. Physical stimuli, such as pressure and vibration, as well as the sensation of sound and body position (balance), are interpreted

through a **mechanoreceptor**. Light is detected by **photoreceptors** in the eyes. Another physical stimulus that has its own type of receptor is temperature, which is sensed through a **thermoreceptor** that is either sensitive to temperatures above (heat) or below (cold) normal body temperature.

Sensory Modalities

Ask anyone what the senses are, and they are likely to list the five major senses—taste, smell, touch, hearing, and sight. However, these are not all of the senses. The most obvious omission from this list is balance. Also, what is referred to simply as touch can be further subdivided into pressure, vibration, stretch, and hair-follicle position, on the basis of the type of mechanoreceptors that perceive these touch sensations. Other overlooked senses include temperature perception by thermoreceptors and pain perception by nociceptors.

Within the realm of physiology, senses can be classified as either general or special. A **general sense** is one that is distributed throughout the body and has receptor cells within the structures of other organs. Mechanoreceptors in the skin, muscles, or the walls of blood vessels are examples of this type. General senses often contribute to the sense of touch, as described above, or to **proprioception** (body position) and **kinesthesia** (body movement), or to a **visceral sense**, which is most important to autonomic functions. A **special sense** (discussed in Chapter 15) is one that has a specific organ devoted to it, namely the eye, inner ear, tongue, or nose.

Each of the senses is referred to as a **sensory modality**. Modality refers to the way that information is encoded into a perception. The main sensory modalities can be described on the basis of how each

stimulus is transduced and perceived. The chemical senses include taste and smell. The general sense that is usually referred to as touch includes chemical sensation in the form of nociception, or pain. Pressure, vibration, muscle stretch, and the movement of hair by an external stimulus, are all sensed by mechanoreceptors and perceived as touch or proprioception. Hearing and balance are also sensed by mechanoreceptors. Finally, vision involves the activation of photoreceptors.

Listing all the different sensory modalities, which can number as many as 17, involves separating the five major senses into more specific categories, or **submodalities**, of the larger sense. An individual sensory modality represents the sensation of a specific type of stimulus. For example, the general sense of touch, which is known as **somatosensation**, can be separated into light pressure, deep pressure, vibration, itch, pain, temperature, or hair movement.

In this chapter we will discuss the general senses which include pain, temperature, touch, pressure, vibration and proprioception. We will discuss the special senses, which include smell, taste, vision, hearing and the vestibular system, in chapter 15.

Somatosensation (Touch)

Somatosensation is considered a general sense, as opposed to the submodalities discussed in this section. Somatosensation is the group of sensory modalities that are associated with touch and limb position. These modalities include pressure, vibration, light touch, tickle, itch, temperature, pain, proprioception, and kinesthesia. This means that its receptors are not associated with a specialized organ, but are instead spread throughout the body in a variety of organs. Many of the somatosensory receptors are located in the

skin, but receptors are also found in muscles, tendons, joint capsules and ligaments.

Two types of somatosensory signals that are transduced by free nerve endings are pain and temperature. These two modalities use thermoreceptors and nociceptors to transduce temperature and pain stimuli, respectively. Temperature receptors are stimulated when local temperatures differ from body temperature. Some thermoreceptors are sensitive to just cold and others to just heat. Nociception is the sensation of potentially damaging stimuli. Mechanical, chemical, or thermal stimuli beyond a set threshold will elicit painful sensations. Stressed or damaged tissues release chemicals that activate receptor proteins in the nociceptors. For example, the sensation of pain or heat associated with spicy foods involves **capsaicin**, the active molecule in hot peppers. Capsaicin molecules bind to a transmembrane ion channel in nociceptors that is sensitive to temperatures above 37°C. The dynamics of capsaicin binding with this transmembrane ion channel is unusual in that the molecule remains bound for a long time. Because of this, it will decrease the ability of other stimuli to elicit pain sensations through the activated nociceptor. For this reason, capsaicin can be used as a topical analgesic, such as in products like Icy Hot™.

If you drag your finger across a textured surface, the skin of your finger will vibrate. Such low frequency vibrations are sensed by mechanoreceptors called Merkel cells, also known as type I cutaneous mechanoreceptors. Merkel cells are located in the stratum basale of the epidermis. Deep pressure and vibration is transduced by lamellated (Pacinian) corpuscles, which are receptors with encapsulated endings found deep in the dermis, or subcutaneous tissue. Light touch is transduced by the encapsulated endings known as tactile (Meissner's) corpuscles. Follicles are also

wrapped in a plexus of nerve endings known as the hair follicle plexus. These nerve endings detect the movement of hair at the surface of the skin, such as when an insect may be walking along the skin. Stretching of the skin is transduced by stretch receptors known as bulbous corpuscles. Bulbous corpuscles are also known as Ruffini corpuscles, or type II cutaneous mechanoreceptors.

Other somatosensory receptors are found in the joints and muscles. Stretch receptors monitor the stretching of tendons, muscles, and the components of joints. For example, have you ever stretched your muscles before or after exercise and noticed that you can only stretch so far before your muscles spasm back to a less stretched state? This spasm is a reflex that is initiated by stretch receptors to avoid muscle tearing. Such stretch receptors can also prevent over-contraction of a muscle. In skeletal muscle tissue, these stretch receptors are called muscle spindles. Golgi tendon organs similarly transduce the stretch levels of tendons. Bulbous corpuscles are also present in joint capsules, where they measure stretch in the components of the skeletal system within the joint. Additionally, lamellated corpuscles are found adjacent to joint capsules and detect vibrations associated with movement around joints. The types of nerve endings, their locations, and the stimuli they transduce are presented in the table below.

***No corresponding eponymous name.**

Mechanoreceptors of Somatosensation (Table 13.1)			
Name	**Historical (eponymous) name**	**Location(s)**	**Stimuli**

***No corresponding eponymous name.**

Mechanoreceptors of Somatosensation (Table 13.1)			
Name	**Historical (eponymous) name**	**Location(s)**	**Stimuli**
Free nerve endings	*	Dermis, cornea, tongue, joint capsules	Pain, temperature, mechanical deformation
Mechanoreceptors	Merkel's discs	Epidermal–dermal junction, mucosal membranes	Low frequency vibration (5–15 Hz)
Bulbous corpuscle	Ruffini's corpuscle	Dermis, joint capsules	Stretch
Tactile corpuscle	Meissner's corpuscle	Papillary dermis, especially in the fingertips and lips	Light touch, vibrations below 50 Hz
Lamellated	Pacinian	Deep dermis, subcutaneous	Deep pressure, high-frequency

***No corresponding eponymous name.**

Mechanoreceptors of Somatosensation (Table 13.1)			
Name	**Historical (eponymous) name**	**Location(s)**	**Stimuli**
corpuscle	corpuscle	tissue, joint capsules	vibration (around 250 Hz)
Hair follicle plexus	*	Wrapped around hair follicles in the dermis	Movement of hair
Muscle spindle	*	In line with skeletal muscle fibers	Muscle contraction and stretch
Tendon stretch organ	Golgi tendon organ	In line with tendons	Stretch of tendons

Neurons: Structure, functions, types, neural impulse, synaptic transmission. Neurotransmitters.

Key Points

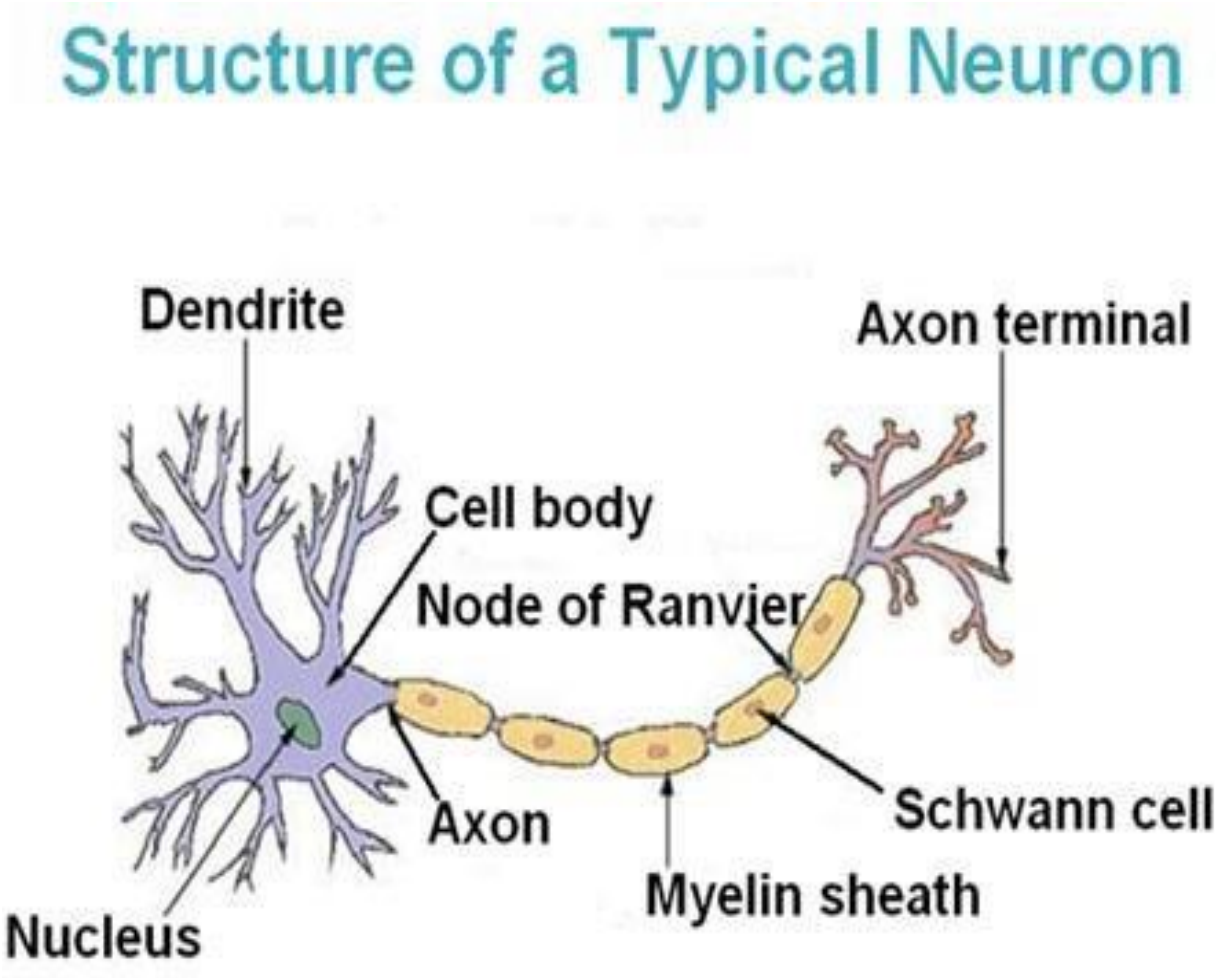
- Neurons are specialized cells that transmit chemical and electrical signals in the brain; they are the basic building blocks of the central nervous system.
- The primary components of the neuron are the soma (cell body), the axon (a long slender projection that conducts electrical impulses away from the cell body), dendrites (tree-like structures that receive messages from other neurons), and synapses (specialized junctions between neurons).
- Some axons are covered with myelin, a fatty material that acts as an insulator and conductor to speed up the process of communication.
- Sensory neurons are neurons responsible for converting external stimuli from the environment into corresponding internal stimuli.
- Motor neurons are neurons located in the central nervous system (CNS); they project their axons outside of the CNS to directly or indirectly control muscles.
- Interneurons act as the “middle men” between sensory and motor neurons, which convert external stimuli to internal stimuli and control muscle movement, respectively.

the The neuron is the basic building block of the brain and central nervous system. Neurons are specialized cells that transmit chemical and electrical signals. The brain is made up entirely of

neurons and glial cells, which are non-neuronal cells that provide structure and support for the neurons. Nearly 86 billion neurons work together within the nervous system to communicate with the rest of the body. They are responsible for everything from consciousness and thought to pain and hunger. There are three primary types of neuron: sensory neurons, motor neurons, and interneurons.

Structures of a Neuron

In addition to having all the normal components of a cell (nucleus, organelles, etc.) neurons also contain unique structures for receiving and sending the electrical signals that make neuronal communication possible.



The structure of a neuron: The above image shows the basic structural components of an average neuron, including the dendrite, cell body, nucleus, Node of Ranvier, myelin sheath, Schwann cell, and axon terminal.

Dendrite

Dendrites are branch-like structures extending away from the cell body, and their job is to receive messages from other neurons and allow those messages to travel to the cell body. Although some neurons do not have any dendrites, other types of neurons have multiple dendrites. Dendrites can have small protrusions called dendritic spines, which further increase surface area for possible connections with other neurons.

Cell Body

Like other cells, each neuron has a cell body (or soma) that contains a nucleus, smooth and rough endoplasmic reticulum, Golgi apparatus, mitochondria, and other cellular components.

Axon

An axon, at its most basic, is a tube-like structure that carries an electrical impulse from the cell body (or from another cell's dendrites) to the structures at opposite end of the neuron—axon terminals, which can then pass the impulse to another neuron. The cell body contains a specialized structure, the axon hillock, which serves as a junction between the cell body and the axon.

Synapse

The synapse is the chemical junction between the axon terminals of one neuron and the dendrites of the next. It is a gap where

specialized chemical interactions can occur, rather than an actual structure.

Function of a Neuron

The specialized structure and organization of neurons allows them to transmit signals in the form of electric impulses from the brain to the body and back. Individually, neurons can pass a signal all the way from their own dendrites to their own axon terminals; but at a higher level neurons are organized in long chains, allowing them to pass signals very quickly from one to the other. One neuron's axon will connect chemically to another neuron's dendrite at the synapse between them. Electrically charged chemicals flow from the first neuron's axon to the second neuron's dendrite, and that signal will then flow from the second neuron's dendrite, down its axon, across a synapse, into a third neuron's dendrites, and so on.

This is the basic chain of neural signal transmission, which is how the brain sends signals to the muscles to make them move, and how sensory organs send signals to the brain. It is important that these signals can happen quickly, and they do. Think of how fast you drop a hot potato—before you even realize it is hot. This is because the sense organ (in this case, the skin) sends the signal "This is hot!" to neurons with very long axons that travel up the spine to the brain. If this didn't happen quickly, people would burn themselves.

Other Structures

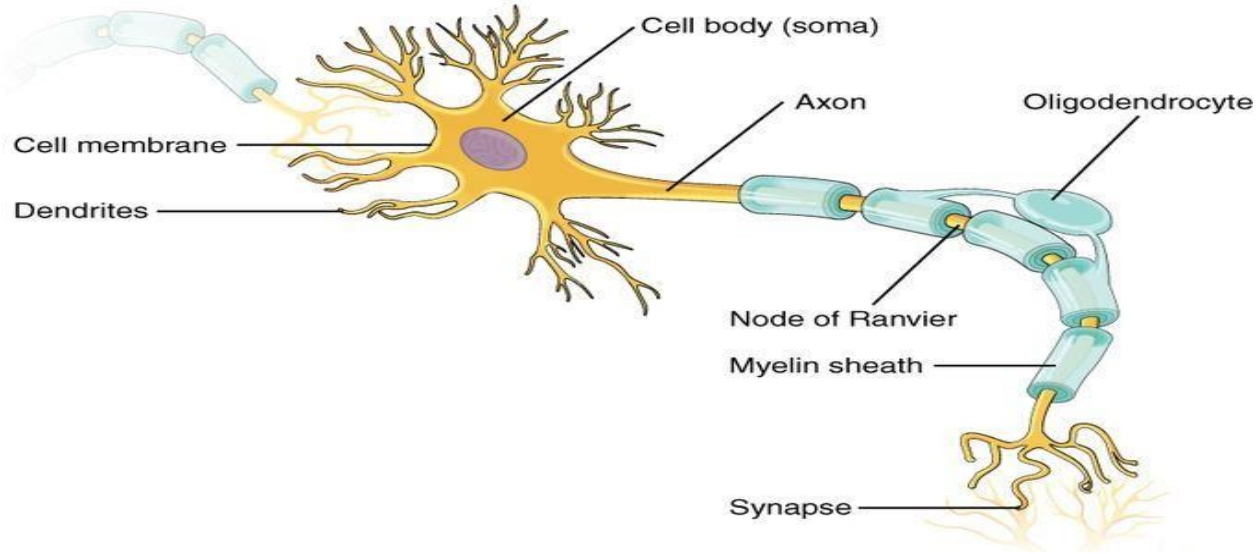
Dendrites, cell bodies, axons, and synapses are the basic parts of a neuron, but other important structures and materials surround neurons to make them more efficient.

Myelin Sheath

Some axons are covered with myelin, a fatty material that wraps around the axon to form the myelin sheath. This external coating functions as insulation to minimize dissipation of the electrical signal as it travels down the axon. Myelin's presence on the axon greatly increases the speed of conduction of the electrical signal, because the fat prevents any electricity from leaking out. This insulation is important, as the axon from a human motor neuron can be as long as a meter—from the base of the spine to the toes. Periodic gaps in the myelin sheath are called nodes of Ranvier. At these nodes, the signal is "recharged" as it travels along the axon.

Glial Cells

The myelin sheath is not actually part of the neuron. Myelin is produced by glial cells (or simply glia, or "glue" in Greek), which are non-neuronal cells that provide support for the nervous system. Glia function to hold neurons in place (hence their Greek name), supply them with nutrients, provide insulation, and remove pathogens and dead neurons. In the central nervous system, the glial cells that form the myelin sheath are called oligodendrocytes; in the peripheral nervous system, they are called Schwann



cells.

Neuron in the central nervous system: This neuron diagram also shows the oligodendrocyte, myelin sheath, and nodes of Ranvier.

Types of Neurons

There are three major types of neurons: sensory neurons, motor neurons, and interneurons. All three have different functions, but the brain needs all of them to communicate effectively with the rest of the body (and vice versa).

Sensory Neurons

Sensory neurons are neurons responsible for converting external stimuli from the environment into corresponding internal stimuli. They are activated by sensory input, and send projections to other elements of the nervous system, ultimately conveying sensory information to the brain or spinal cord. Unlike the motor neurons of the central nervous system (CNS), whose inputs come from other neurons, sensory neurons are activated by physical modalities (such as visible light, sound, heat, physical contact, etc.) or by chemical signals (such as smell and taste).

Most sensory neurons are pseudounipolar, meaning they have an axon that branches into two extensions—one connected to dendrites that receive sensory information and another that transmits this information to the spinal cord.

Multipolar and pseudounipolar neurons: This diagram shows the difference between: 1) a unipolar neuron; 2) a bipolar neuron; 3) a multipolar neuron; 4) a pseudounipolar neuron.

Motor Neurons

Motor neurons are neurons located in the central nervous system, and they project their axons outside of the CNS to directly or indirectly control muscles. The interface between a motor neuron and muscle fiber is a specialized synapse called the neuromuscular junction. The structure of motor neurons is multipolar, meaning each cell contains a single axon and multiple dendrites. This is the most common type of neuron.

Interneurons

Interneurons are neither sensory nor motor; rather, they act as the "middle men" that form connections between the other two types. Located in the CNS, they operate locally, meaning their axons connect only with nearby sensory or motor neurons. Interneurons can save time and therefore prevent injury by sending messages to the spinal cord and back instead of all the way to the brain. Like motor neurons, they are multipolar in structure.

Stages of the Action Potential

Neural impulses occur when a stimulus depolarizes a cell membrane, prompting an action potential which sends an "all or nothing" signal.

Neural Impulses in the Nervous System

The central nervous system (CNS) goes through a three-step process when it functions: sensory input, neural processing, and motor output. The sensory input stage is when the neurons (or excitable nerve cells) of the sensory organs are excited electrically. Neural impulses from sensory receptors are sent to the brain and spinal cord for processing. After the brain has processed the information, neural impulses are then conducted from the brain and

spinal cord to muscles and glands, which is the resulting motor output.

A neuron affects other neurons by releasing a neurotransmitter that binds to chemical receptors. The effect upon the postsynaptic (receiving) neuron is determined not by the presynaptic (sending) neuron or by the neurotransmitter itself, but by the type of receptor that is activated. A neurotransmitter can be thought of as a key, and a receptor as a lock: the key unlocks a certain response in the postsynaptic neuron, communicating a particular signal. However, in order for a presynaptic neuron to release a neurotransmitter to the next neuron in the chain, it must go through a series of changes in electric potential.

Stages of Neural Impulses

" Resting potential " is the name for the electrical state when a neuron is not actively being signaled. A neuron at resting potential has a membrane with established amounts of sodium (Na+) and potassium (K+) ions on either side, leaving the inside of the neuron negatively charged relative to the outside.

The action potential is a rapid change in polarity that moves along the nerve fiber from neuron to neuron. In order for a neuron to move from resting potential to action potential—a short-term electrical change that allows an electrical signal to be passed from one neuron to another—the neuron must be stimulated by pressure, electricity, chemicals, or another form of stimuli. The level of stimulation that a neuron must receive to reach action potential is known as the threshold of excitation, and until it reaches that threshold, nothing will happen. Different neurons are sensitive to different stimuli, although most can register pain.

The action potential has several stages.

1. Depolarization: A stimulus starts the depolarization of the membrane. Depolarization, also referred to as the “upswing,” is caused when positively charged sodium ions rush into a nerve cell. As these positive ions rush in, the membrane of the stimulated cell reverses its polarity so that the outside of the membrane is negative relative to the inside.
2. Repolarization. Once the electric gradient has reached the threshold of excitement, the “downswing” of repolarization begins. The channels that let the positive sodium ion channels through close up, while channels that allow positive potassium ions open, resulting in the release of positively charged potassium ions from the neuron. This expulsion acts to restore the localized negative membrane potential of the cell, bringing it back to its normal voltage.
3. Refractory Phase. The refractory phase takes place over a short period of time after the depolarization stage. Shortly after the sodium gates open, they close and go into an inactive conformation. The sodium gates cannot be opened again until the membrane is repolarized to its normal resting potential. The sodium-potassium pump returns sodium ions to the outside and potassium ions to the inside. During the refractory phase this particular area of the nerve cell membrane cannot be depolarized. Therefore, the neuron cannot reach action potential during this “rest period.”

S**ynapses**

The synapse is the junction where neurons trade information. It is not a physical component of a cell but rather a name for the gap between two cells: the presynaptic cell (giving the signal) and the

postsynaptic cell (receiving the signal). There are two types of possible reactions at the synapse—chemical or electrical. During a chemical reaction, a chemical called a neurotransmitter is released from one cell into another. In an electrical reaction, the electrical charge of one cell is influenced by the charge an adjacent cell.

All synapses have a few common characteristics:

- Presynaptic cell: a specialized area within the axon of the giving cell that transmits information to the dendrite of the receiving cell.
- Synaptic cleft: the small space at the synapse that receives neurotransmitters.
- G-protein coupled receptors: receptors that sense molecules outside the cell and thereby activate signals within it.
- Ligand-gated ion channels: receptors that are opened or closed in response to the binding of a chemical messenger.
- Postsynaptic cell: a specialized area within the dendrite of the receiving cell that contains receptors designed to process neurotransmitters.

The Electrical Synapse

The stages of an electrical reaction at a synapse are as follows:

1. Resting potential. The membrane of a neuron is normally at rest with established concentrations of sodium ions (Na+) and potassium ions (K+) on either side. The membrane potential (or, voltage across the membrane) at this state is -70 mV, with the inside being negative relative to the outside.

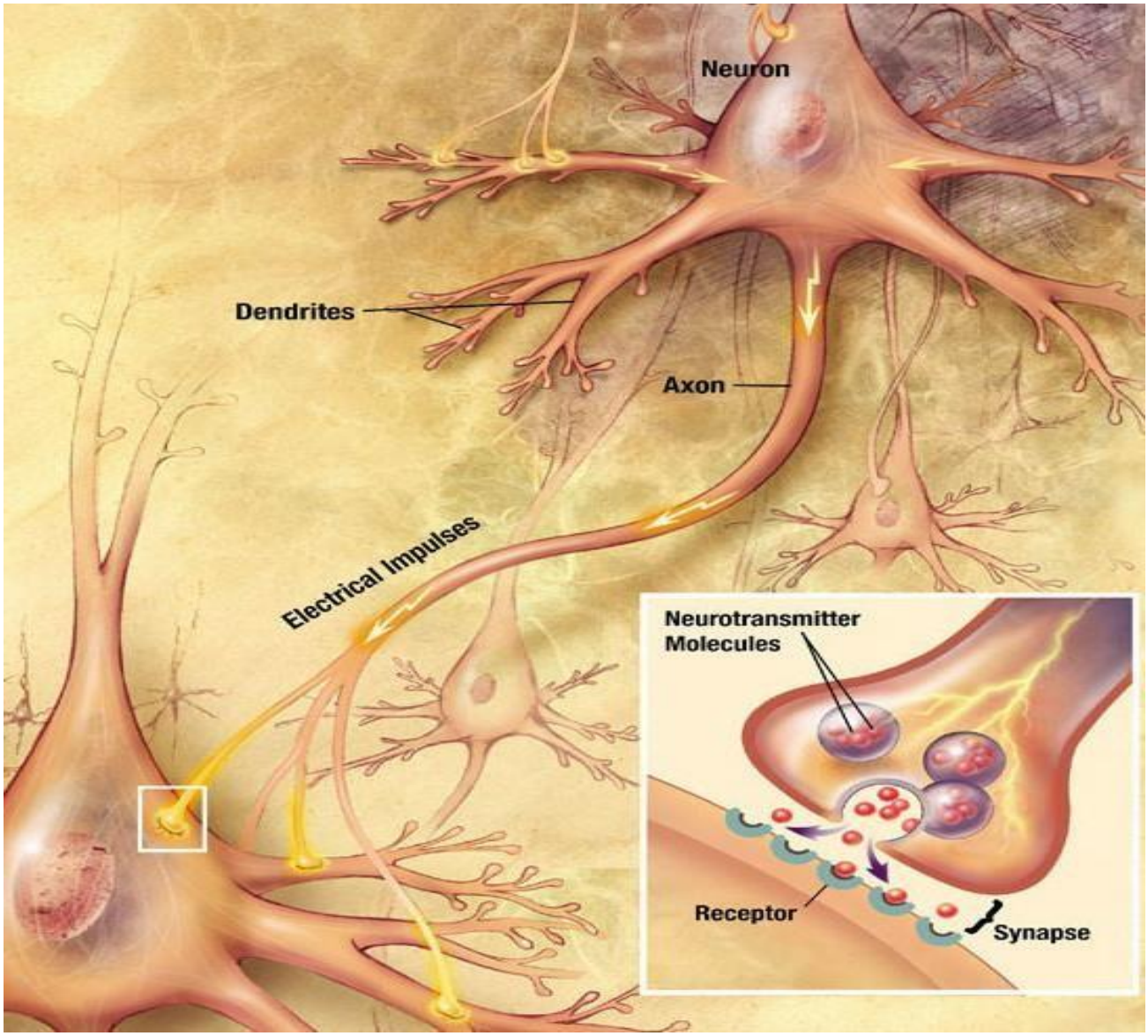
2. Depolarization. A stimulus begins the depolarization of the membrane. Depolarization, also referred to as the “upswing,” occurs when positively charged sodium ions (Na+) suddenly rush through open sodium gates into a nerve cell. If the membrane potential reaches -55 mV, it has reached the threshold of excitation. Additional sodium rushes in, and the membrane of the stimulated cell actually reverses its polarity so that the outside of the membrane is negative relative to the inside. The change in voltage stimulates the opening of additional sodium channels (called a voltage-gated ion channel), providing what is known as a positive feedback loop. Eventually, the cell potential reaches +40 mV, or the action potential.

3. Repolarization. The “downswing” of repolarization is caused by the closing of sodium ion channels and the opening of potassium ion channels, resulting in the release of positively charged potassium ions (K+) from the nerve cell. This expulsion acts to restore the localized negative membrane potential of the cell.

4. Refractory Phase. The refractory phase is a short period of time after the repolarization stage. Shortly after the sodium gates open, they close and go into an inactive conformation where the cell’s membrane potential is actually even lower than its baseline -70 mV. The sodium gates cannot be opened again until the membrane has completely repolarized to its normal resting potential, -70 mV. The sodium-potassium pump returns sodium ions to the outside and potassium ions to the inside. During the refractory phase this particular area of the nerve cell membrane cannot be depolarized; the cell cannot be excited.

The Chemical Synapse

The process of a chemical reaction at the synapse has some important differences from an electrical reaction. Chemical synapses are much more complex than electrical synapses, which makes them slower, but also allows them to generate different results. Like electrical reactions, chemical reactions involve electrical modifications at the postsynaptic membrane, but chemical reactions also require chemical messengers, such as neurotransmitters, to operate.



Neuron & chemical synapse: This image shows electric impulses traveling between neurons; the inset shows a chemical reaction occurring at the synapse.

A basic chemical reaction at the synapse undergoes a few additional steps:

1. The action potential (which occurs as described above) travels along the membrane of the presynaptic cell until it reaches the synapse. The electrical depolarization of the membrane at the synapse causes channels to open that are selectively permeable, meaning they specifically only allow the entry of positive sodium ions (Na+).
2. The ions flow through the presynaptic membrane, rapidly increasing their concentration in the interior.
3. The high concentration activates a set of ion-sensitive proteins attached to vesicles, which are small membrane compartments that contain a neurotransmitter chemical.
4. These proteins change shape, causing the membranes of some “docked” vesicles to fuse with the membrane of the presynaptic cell. This opens the vesicles, which releases their neurotransmitter contents into the synaptic cleft, the narrow space between the membranes of the pre- and postsynaptic cells.
5. The neurotransmitter diffuses within the cleft. Some of it escapes, but the rest of it binds to chemical receptor molecules located on the membrane of the postsynaptic cell.
6. The binding of neurotransmitter causes the receptor molecule to be activated in some way. Several types of activation are possible, depending on what kind of neurotransmitter was

released. In any case, this is the key step by which the synaptic process affects the behavior of the postsynaptic cell.

7. Due to thermal shaking, neurotransmitter molecules eventually break loose from the receptors and drift away.
8. The neurotransmitter is either reabsorbed by the presynaptic cell and repackaged for future release, or else it is broken down metabolically.

Differences Between Electrical and Chemical Synapses

- Electrical synapses are faster than chemical synapses because the receptors do not need to recognize chemical messengers. The synaptic delay for a chemical synapse is typically about 2 milliseconds, while the synaptic delay for an electrical synapse may be about 0.2 milliseconds.
- Because electrical synapses do not involve neurotransmitters, electrical neurotransmission is less modifiable than chemical neurotransmission.
- The response is always the same sign as the source. For example, depolarization of the presynaptic membrane will always induce a depolarization in the postsynaptic membrane, and vice versa for hyperpolarization.
- The response in the postsynaptic neuron is generally smaller in amplitude than the source. The amount of attenuation of the signal is due to the membrane resistance of the presynaptic and postsynaptic neurons.
- Long-term changes can be seen in electrical synapses. For example, changes in electrical synapses in the retina are seen during light and dark adaptations of the retina.

Neurotransmitters

Neurotransmitters are chemicals that transmit signals from a neuron across a synapse to a target cell. **KEY TAKEAWAYS**

Key Points

- Neurotransmitters dictate communication between cells by binding to specific receptors and depolarizing or hyperpolarizing the cell.
- Inhibitory neurotransmitters cause hyperpolarization of the postsynaptic cell; excitatory neurotransmitters cause depolarization of the postsynaptic cell.
- Too little of a neurotransmitter may cause the overaccumulation of proteins, leading to disorders like Alzheimer's; too much of a neurotransmitter may block receptors required for proper brain function, leading to disorders like schizophrenia.
- The three neurotransmitter systems in the brain are cholinergic, amino acids, and biogenic amines.

Key Terms

- **reuptake**: The reabsorption of a neurotransmitter by a neuron after the transmission of a neural impulse across a synapse.
- **vesicle**: A membrane-bound compartment found in a cell.
- **action potential**: A short-term change in the electrical potential that travels along a cell (such as a nerve or muscle fiber); the basis of neural communication.

Neurotransmitters are chemicals that transmit signals from a neuron to a target cell across a synapse. When called upon to deliver messages, they are released from their synaptic vesicles on the presynaptic (giving) side of the synapse, diffuse across the synaptic cleft, and bind to receptors in the membrane on the postsynaptic (receiving) side.

An action potential is necessary for neurotransmitters to be released, which means that neurons must reach a certain threshold of electric stimulation in order to complete the reaction. A neuron has a negative charge inside the cell membrane relative to the outside of the cell membrane; when stimulation occurs and the neuron reaches the threshold of excitement this polarity is reversed. This allows the signal to pass through the neuron. When the chemical message reaches the axon terminal, channels in the postsynaptic cell membrane open up to receive neurotransmitters from vesicles in the presynaptic cell.

Inhibitory neurotransmitters cause hyperpolarization of the postsynaptic cell (that is, decreasing the voltage gradient of the cell, thus bringing it further away from an action potential), while excitatory neurotransmitters cause depolarization (bringing it closer to an action potential). Neurotransmitters match up with receptors like a key in a lock. A neurotransmitter binds to its receptor and will not bind to receptors for other neurotransmitters, making the binding a specific chemical event.

There are several systems of neurotransmitters found at various synapses in the nervous system. The following groups refer to the specific chemicals, and within the groups are specific systems, some of which block other chemicals from entering the cell and some of which permit the entrance of chemicals that were blocked before.

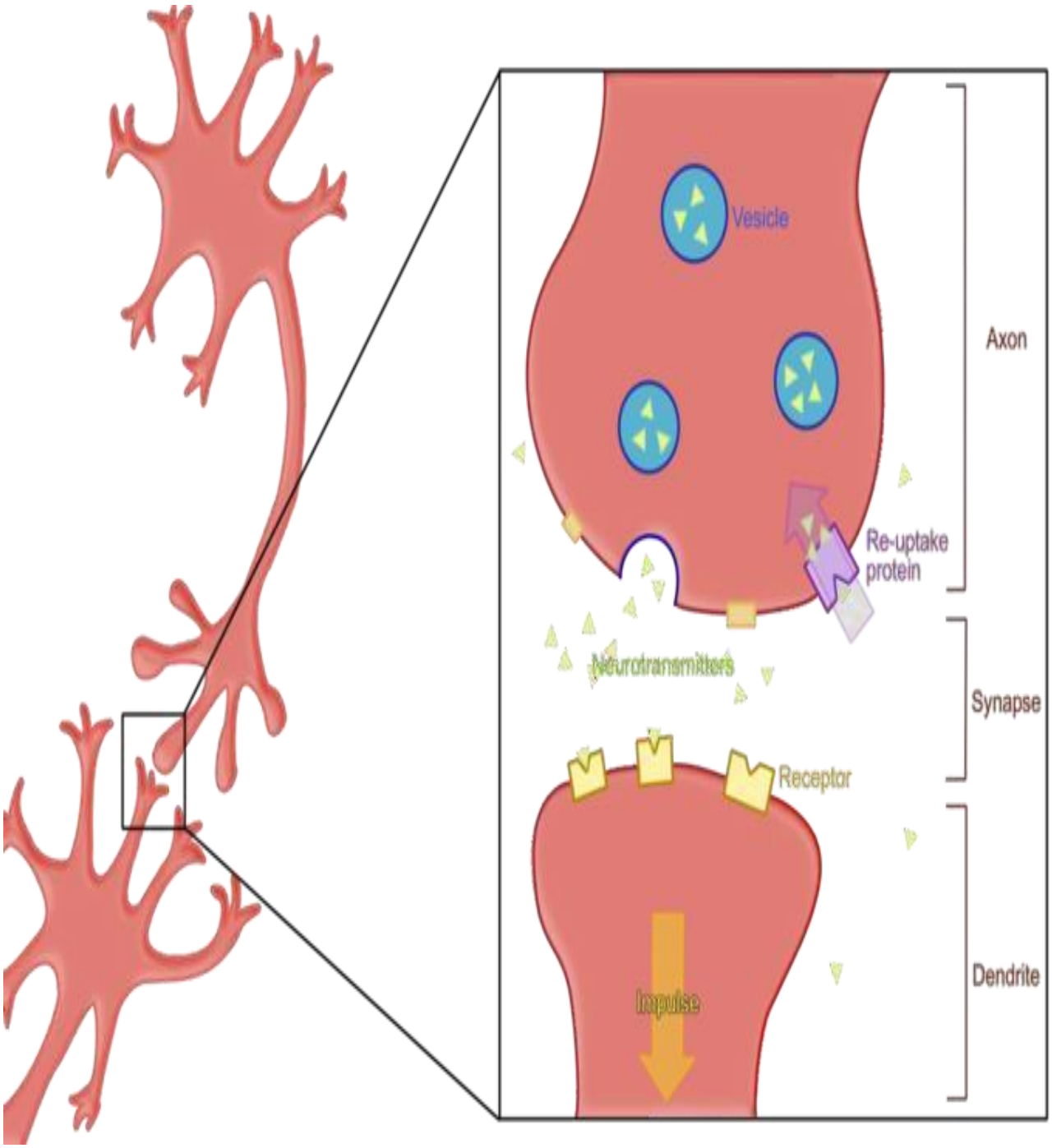
Cholinergic System

The cholinergic system is a neurotransmitter system of its own, and is based on the neurotransmitter acetylcholine (ACh). This system is found in the autonomic nervous system, as well as distributed throughout the brain.

The cholinergic system has two types of receptors: the nicotinic receptor and the acetylcholine receptor, which is known as the muscarinic receptor. Both of these receptors are named for chemicals that interact with the receptor in addition to the neurotransmitter acetylcholine. Nicotine, the chemical in tobacco, binds to the nicotinic receptor and activates it similarly to acetylcholine. Muscarine, a chemical product of certain mushrooms, binds to the muscarinic receptor. However, they cannot bind to each others' receptors.

Amino Acids

Another group of neurotransmitters are amino acids, including glutamate (Glu), GABA (gamma-aminobutyric acid, a derivative of glutamate), and glycine (Gly). These amino acids have an amino group and a carboxyl group in their chemical structures. Glutamate is one of the 20 amino acids used to make proteins. Each amino acid neurotransmitter is its own system, namely the glutamatergic, GABAergic, and glycinergic systems. They each have their own receptors and do not interact with each other. Amino acid neurotransmitters are eliminated from the synapse by reuptake. A pump in the cell membrane of the presynaptic element, or sometimes a neighboring glial cell, clears the amino acid from the synaptic cleft so that it can be recycled, repackaged in vesicles, and released again.



The reuptake process: This illustration shows the process of reuptake, in which leftover neurotransmitters are returned to vesicles in the presynaptic cell.

Biogenic Amines

Another class of neurotransmitter is the biogenic amine, a group of neurotransmitters made enzymatically from amino acids. They have amino groups in them, but do not have carboxyl groups and are therefore no longer classified as amino acids.

Neuropeptides

A neuropeptide is a neurotransmitter molecule made up of chains of amino acids connected by peptide bonds, similar to proteins. However, proteins are long molecules while some neuropeptides are quite short. Neuropeptides are often released at synapses in combination with another neurotransmitter.

Dopamine

Dopamine is the best-known neurotransmitter of the catecholamine group. The brain includes several distinct dopamine systems, one of which plays a major role in reward-motivated behavior. Most types of reward increase the level of dopamine in the brain, and a variety of addictive drugs increase dopamine neuronal activity. Other brain dopamine systems are involved in motor control and in controlling the release of several other important hormones.

Effect on the Synapse

The effect of a neurotransmitter on the postsynaptic element is entirely dependent on the receptor protein. If there is no receptor protein in the membrane of the postsynaptic element, then the neurotransmitter has no effect. The depolarizing (more likely to reach an action potential) or hyperpolarizing (less likely to reach an action potential) effect is also dependent on the receptor. When acetylcholine binds to the nicotinic receptor, the postsynaptic cell is depolarized. However, when acetylcholine binds to the muscarinic

receptor, it might cause depolarization or hyperpolarization of the target cell.

The amino acid neurotransmitters (glutamate, glycine, and GABA) are almost exclusively associated with just one effect. Glutamate is considered an excitatory amino acid because Glu receptors in the adult cause depolarization of the postsynaptic cell. Glycine and GABA are considered inhibitory amino acids, again because their receptors cause hyperpolarization, making the receiving cell less likely to reach an action potential.

The Right Dose

Sometimes too little or too much of a neurotransmitter may affect an organism's behavior or health. The underlying cause of some neurodegenerative diseases, such as Parkinson's, appears to be related to overaccumulation of proteins, which under normal circumstances would be regulated by the presence of dopamine. On the other hand, when an excess of the neurotransmitter dopamine blocks glutamate receptors, disorders like schizophrenia can occur.

The Structure of Neural Networks

The connections between neurons form a highly complex network. The basic kinds of connections between neurons are chemical synapses and electrical gap junctions, through which either chemical or electrical impulses are communicated between neurons. The method through which neurons interact with neighboring neurons usually consists of several axon terminals connecting through synapses to the dendrites on other neurons.

If a stimulus creates a strong enough input signal in a nerve cell, the neuron sends an action potential and transmits this signal along its axon. The axon of a nerve cell is responsible for transmitting

information over a relatively long distance, and so most neural pathways are made up of axons. Some axons are encased in a lipid-coated myelin sheath, making them appear a bright white; others that lack myelin sheaths (i.e., are unmyelinated) appear a darker beige color, which is generally called gray.

The process of synaptic transmission in neurons: Neurons interact with other neurons by sending a signal, or impulse, along their axon and across a synapse to the dendrites of a neighboring neuron.

Some neurons are responsible for conveying information over long distances. For example, motor neurons, which travel from the spinal cord to the muscle, can have axons up to a meter in length in humans. The longest axon in the human body is almost two meters long in tall individuals and runs from the big toe to the medulla oblongata of the brain stem.

The Capacity of Neural Networks

The basic neuronal function of sending signals to other cells includes the capability for neurons to exchange signals with each other. Networks formed by interconnected groups of neurons are capable of a wide variety of functions, including feature detection, pattern generation, and timing. In fact, it is difficult to assign limits to the types of information processing that can be carried out by neural networks. Given that individual neurons can generate complex temporal patterns of activity independently, the range of capabilities possible for even small groups of neurons are beyond current understanding. However, we do know that we have neural networks to thank for much of our higher cognitive functioning.

Behaviorist Approach

Historically, the predominant view of the function of the nervous system was as a stimulus-response associator. In this conception, neural processing begins with stimuli that activate sensory neurons, producing signals that propagate through chains of connections in the spinal cord and brain, giving rise eventually to activation of motor neurons and thereby to muscle contraction or other overt responses. Charles Sherrington, in his influential 1906 book The Integrative Action of the Nervous System, developed the concept of stimulus-response mechanisms in much more detail, and behaviorism, the school of thought that dominated psychology through the middle of the 20th century, attempted to explain every aspect of human behavior in stimulus-response terms.

Hybrid Approach

However, experimental studies of electrophysiology, beginning in the early 20th century and reaching high productivity by the 1940s, showed that the nervous system contains many mechanisms for generating patterns of activity intrinsically—without requiring an external stimulus. Neurons were found to be capable of producing regular sequences of action potentials (“firing”) even in complete isolation. When intrinsically active neurons are connected to each other in complex circuits, the possibilities for generating intricate temporal patterns become far more extensive. A modern conception views the function of the nervous system partly in terms of stimulus-response chains, and partly in terms of intrinsically generated activity patterns; both types of activity interact with each other to generate the full repertoire of behavior.

Hebbian Theory

In 1949, neuroscientist Donald Hebb proposed that simultaneous activation of cells leads to pronounced increase in synaptic strength between those cells, a theory that is widely accepted today. Cell assembly, or Hebbian theory, asserts that “cells that fire together wire together,” meaning neural networks can be created through associative experience and learning. Since Hebb’s discovery, neuroscientists have continued to find evidence of plasticity and modification within neural networks.

What is The Central and Peripheral Nervous Systems – Structure and functions. Neuroplasticity ?

The Central and Peripheral Nervous Systems – Structure and functions. Neuroplasticity

The Central Nervous System

- The central nervous system consists of the brain and spinal cord.
- The brain plays a central role in the control of most bodily functions, including awareness, movements, sensations, thoughts, speech, and memory.
- Some reflex movements can occur via spinal cord pathways without the participation of brain structures.

- The spinal cord is connected to a section of the brain called the brainstem and runs through the spinal canal.
- Cranial nerves exit the brainstem.
- Nerve roots exit the spinal cord to both sides of the body.
- The spinal cord carries signals (messages) back and forth between the brain and the peripheral nerves.
- Cerebrospinal fluid surrounds the brain and the spinal cord and also circulates within the cavities (called ventricles) of the central nervous system.
- The leptomeninges surround the brain and the spinal cord.
- The cerebrospinal fluid circulates between 2 meningeal layers called the
    - pia matter and
    - the arachnoid
    - (or pia-arachnoid membranes).
- The outer, thicker layer serves the role of a protective shield and is called the dura matter.
- The basic unit of the central nervous system is the neuron (nerve cell).
    - Billions of neurons allow the different parts of the body to communicate with each other via the brain and the spinal cord.
    - A fatty material called myelin coats nerve cells to insulate them and to allow nerves to communicate quickly.

Brain and Cerebrum Location

The cerebrum is the largest part of the brain and controls voluntary actions, speech, senses, thought, and memory.

The surface of the cerebral cortex has grooves or infoldings (called sulci), the largest of which are termed fissures. Some fissures separate lobes.

The convolutions of the cortex give it a wormy appearance. Each convolution is delimited by two sulci and is also called a gyrus (gyri in plural). The cerebrum is divided into two halves, known as the right and left hemispheres. A mass of fibers called the corpus callosum links the hemispheres. The right hemisphere controls voluntary limb movements on the left side of the body, and the left hemisphere controls voluntary limb movements on the right side of the body. Almost every person has one dominant hemisphere. Each hemisphere is divided into four lobes, or areas, which are interconnected.

- The frontal lobes are located in the front of the brain and are responsible for voluntary movement and, via their connections with other lobes, participate in the execution of sequential tasks; speech output; organizational skills; and certain aspects of behavior, mood, and memory.
- The parietal lobes are located behind the frontal lobes and in front of the occipital lobes. They process sensory information such as temperature, pain, taste, and touch. In addition, the processing includes information about numbers, attentiveness to the position of one's body parts, the space around one's body, and one's relationship to this space.

- The temporal lobes are located on each side of the brain. They process memory and auditory (hearing) information and speech and language functions.
- The occipital lobes are located at the back of the brain. They receive and process visual information.

The cortex, also called gray matter, is the most external layer of the brain and predominantly contains neuronal bodies (the part of the neurons where the DNA-containing cell nucleus is located). The gray matter participates actively in the storage and processing of information. An isolated clump of nerve cell bodies in the gray matter is termed a nucleus (to be differentiated from a cell nucleus). The cells in the gray matter extend their projections, called axons, to other areas of the brain.

Fibers that leave the cortex to conduct impulses toward other areas are termed efferent fibers, and fibers that approach the cortex from other areas of the nervous system are termed afferent (nerves or pathways). Fibers that go from the motor cortex to the brainstem (for example, the pons) or the spinal cord receive a name that generally reflects the connections (that is, corticopontine tract for the former and corticospinal tract for the latter). Axons are surrounded in their course outside the gray matter by myelin, which has a glistening whitish appearance and thus gives rise to the term white matter.

Cortical areas receive their names according to their general function or lobe name. If in charge of motor function, the area is called the motor cortex. If in charge of sensory function, the area is called a sensory or somesthetic cortex. The calcarine or visual cortex is located in the occipital lobe (also termed occipital cortex) and receives visual input. The auditory cortex, localized in the

temporal lobe, processes sounds or verbal input. Knowledge of the anatomical projection of fibers of the different tracts and the relative representation of body regions in the cortex often enables doctors to correctly locate an injury and its relative size, sometimes with great precision.

Central Structures of the Brain

The central structures of the brain include the thalamus, hypothalamus, and pituitary gland. The hippocampus is located in the temporal lobe but participates in the processing of memory and emotions and is interconnected with central structures. Other structures are the basal ganglia, which are made up of gray matter and include the amygdala (localized in the temporal lobe), the caudate nucleus, and the lenticular nucleus (putamen and globus pallidus). Because the caudate and putamen are structurally similar, neuropathologists have coined for them the collective term striatum.

- The thalamus integrates and relays sensory information to the cortex of the parietal, temporal, and occipital lobes. The thalamus is located in the lower central part of the brain (that is, upper part of the brainstem) and is located medially to the basal ganglia. The brain hemispheres lie on the thalamus. Other roles of the thalamus include motor and memory control.
- The hypothalamus, located below the thalamus, regulates automatic functions such as appetite, thirst, and body temperature. It also secretes hormones that stimulate or suppress the release of hormones (for example, growth hormones) in the pituitary gland.
- The pituitary gland is located at the base of the brain. The pituitary gland produces hormones that control many functions of other endocrine glands. It regulates the production of many

hormones that have a role in growth, metabolism, sexual response, fluid and mineral balance, and the stress response.

- The ventricles are cerebrospinal fluid-filled cavities in the interior of the cerebral hemispheres.

Base of the Brain

The base of the brain contains the cerebellum and the brainstem. These structures serve complex functions. Below is a simplified version of these roles:

- Traditionally, the cerebellum has been known to control equilibrium and coordination and contributes to the generation of muscle tone. It has more recently become evident, however, that the cerebellum plays more diverse roles such as participating in some types of memory and exerting a complex influence on musical and mathematical skills.
- The brainstem connects the brain with the spinal cord. It includes the midbrain, the pons, and the medulla oblongata. It is a compact structure in which multiple pathways traverse from the brain to the spinal cord and vice versa. For instance, nerves that arise from cranial nerve nuclei are involved with eye movements and exit the brainstem at several levels. Damage to the brainstem can therefore affect a number of bodily functions. For instance, if the corticospinal tract is injured, a loss of motor function (paralysis) occurs, and it may be accompanied by other neurologic deficits, such as eye movement abnormalities, which are reflective of injury to cranial nerves or their pathways in the brainstem.

- The midbrain is located below the hypothalamus. Some cranial nerves that are also responsible for eye muscle control exit the midbrain.
- The pons serves as a bridge between the midbrain and the medulla oblongata. The pons also contains the nuclei and fibers of nerves that serve eye muscle control, facial muscle strength, and other functions.
- The medulla oblongata is the lowest part of the brainstem and is interconnected with the cervical spinal cord. The medulla oblongata also helps control involuntary actions, including vital processes, such as heart rate, blood pressure, and respiration, and it carries the corticospinal (that is, motor function) tract toward the spinal cord.

Peripheral Nervous System Function

Nerve fibers that exit the brainstem and spinal cord become part of the peripheral nervous system. Cranial nerves exit the brainstem and function as peripheral nervous system mediators of many functions, including eye movements, facial strength and sensation, hearing, and taste.

The optic nerve is considered a cranial nerve but it is generally affected in a disease of the central nervous system known as multiple sclerosis, and, for this and other reasons, it is thought to represent an extension of the central nervous system apparatus that controls vision. In fact, doctors can diagnose inflammation of the head of the optic nerve by using an ophthalmoscope, as if the person's eyes were a window into the central nervous system.

Nerve roots leave the spinal cord to the exit point between two vertebrae and are named according to the spinal cord segment from

which they arise (a cervical eight nerve root arises from cervical spinal cord segment eight). Nerve roots are located anterior with relation to the cord if efferent (for example, carrying input toward limbs) or posterior if afferent (for example, to spinal cord).

Fibers that carry motor input to limbs and fibers that bring sensory information from the limbs to the spinal cord grow together to form a mixed (motor and sensory) peripheral nerve. Some lumbar and all sacral nerve roots take a long route downward in the spinal canal before they exit in a bundle that resembles a horse's tail, hence its name, cauda equina.

The spinal cord is also covered, like the brain, by the pia matter and the arachnoid membranes. The cerebrospinal fluid circulates around the pia and below the outer arachnoid, and this space is also termed the subarachnoid space. The roots of the cauda equina and the rootlets that make up the nerve roots from higher segments are bathed in cerebrospinal fluid. The dura surrounds the pia-arachnoid of the spinal cord, as it does for the brain.

The neuroanatomical basis for multiple brain functions is oversimplified in the above summary. A good example is the neuroanatomical substrate for memory function. Damage to multiple areas of the brain can affect memory. These include structures such as the frontal and temporal lobes, the thalamus, the cerebellum, the putamen, mamillary bodies and fornix, and a convolution above the corpus callosum known as the cingulate gyrus. These structures are variably involved in complex processes such as the storing, processing, or retrieval of memories.

Spinal Cord Nerves

The spinal cord is an extension of the brain and is surrounded by the vertebral bodies that form the spinal column (see Multimedia File 3). The central structures of the spinal cord are made up of gray matter (nerve cell bodies), and the external or surrounding tissues are made up of white matter.

Within the spinal cord are 30 segments that belong to 4 sections (cervical, thoracic, lumbar, sacral), based on their location:

- **Eight cervical segments:** These transmit signals from or to areas of the head, neck, shoulders, arms, and hands.
- **Twelve thoracic segments:** These transmit signals from or to part of the arms and the anterior and posterior chest and abdominal areas.
- **Five lumbar segments:** These transmit signals from or to the legs and feet and some pelvic organs.
- **Five sacral segments:** These transmit signals from or to the lower back and buttocks, pelvic organs and genital areas, and some areas in the legs and feet.
- **A coccygeal remnant** is located at the bottom of the spinal cord.

The Peripheral Nervous System

What exactly is the peripheral nervous system and what role does it play in the body? First, it is important to realize that the nervous system is divided into two parts: the central nervous system and the peripheral nervous system.

The central nervous system includes the brain and spinal cord, while the peripheral nervous system includes all of the nerves that branch out from the brain and spinal cord and extend to other parts of the body including muscles and organs. Each part of the system plays a vital role in how information is communicated throughout the body.

What Is the Peripheral Nervous System?

The peripheral nervous system (PNS) is the division of the nervous system containing all the nerves that lie outside of the central nervous system (CNS). The primary role of the PNS is to connect the CNS to the organs, limbs, and skin. These nerves extend from the central nervous system to the outermost areas of the body.

The peripheral system allows the brain and spinal cord to receive and send information to other areas of the body, which allows us to react to stimuli in our environment.

The nerves that make up the peripheral nervous system are actually the axons or bundles of axons from nerve cells or neurons. In some cases, these nerves are very small but some nerve bundles are so large that they can be easily seen by the human eye.

The peripheral nervous system itself is divided into two parts: the somatic nervous system and the autonomic nervous system.

Each of these components plays a critical role in how the peripheral nervous system operates.

The Somatic Nervous System

The somatic system is the part of the peripheral nervous system responsible for carrying sensory and motor information to and from

the central nervous system. The somatic nervous system derives its name from the Greek word soma, which means "body."

The somatic system is responsible for transmitting sensory information as well as for voluntary movement. This system contains two major types of neurons:

- **Motor neurons**: Also called efferent neurons, motor neurons carry information from the brain and spinal cord to muscle fibers throughout the body. These motor neurons allow us to take physical action in response to stimuli in the environment.
- **Sensory neurons**: Also called afferent neurons, sensory neurons carry information from the nerves to the central nervous system. It is these sensory neurons that allow us to take in sensory information and send it to the brain and spinal cord.

In other words, it is the autonomic system that controls aspects of the body that are usually not under voluntary control. This system allows these functions to take place without needing to consciously think about them happening. The autonomic system is further divided into two branches:

- **Parasympathetic system:** This helps maintain normal body functions and conserve physical resources. Once a threat has passed, this system will slow the heart rate, slow breathing, reduce blood flow to muscles, and constrict the pupils. This allows us to return our bodies to a normal resting state.
- **Sympathetic system:** By regulating the flight-or-fight response,[1] the sympathetic system prepares the body to expend energy to respond to environmental threats. When action is needed, the sympathetic system triggers a response

by accelerating heart rate, increasing breathing rate, boosting blood flow to muscles, activating sweat secretion, and dilating the pupils.

Structure

The peripheral nervous system is itself classified into two systems: the somatic nervous system and the autonomic nervous system. Each system contains afferent and efferent components.

The **afferent** arm consists of sensory (or afferent) neurons running from receptors for stimuli to the CNS. Afferent nerves detect the external environment via receptors for external stimuli such as sight, hearing, pressure, temperature etc. Afferent nerves exist in both the somatic and autonomic nervous systems as both can use sensory signals to alter their activity.

The **efferent** arm consists of motor (or efferent) neurons running from the CNS to the effector organ. Effector organs can either be muscles or glands.

The efferent nerves of the **somatic nervous system** of the PNS is responsible for voluntary, conscious control of skeletal muscles (effector organ) using motor (efferent) nerves.

The efferent nerves of the **autonomic (visceral) nervous system** control the visceral functions of the body. These visceral functions include the regulation of heart rate, digestion, salivation, urination, digestion and many more. The efferent arm of this system can be further subdivided into parasympathetic motor or sympathetic motor.

The **enteric nervous system** is sometimes classified as a separate component of the autonomic nervous system and is sometimes even considered a third independent branch of the PNS.

Neuroplasticity:

The brain's ability to reorganize itself by forming new neural connections throughout life. Neuroplasticity allows the neurons (nerve cells) in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment.

Brain reorganization takes place by mechanisms such as "axonal sprouting" in which undamaged axons grow new nerve endings to reconnect neurons whose links were injured or severed. Undamaged axons can also sprout nerve endings and connect with other undamaged nerve cells, forming new neural pathways to accomplish a needed function.

For example, if one hemisphere of the brain is damaged, the intact hemisphere may take over some of its functions. The brain compensates for damage in effect by reorganizing and forming new connections between intact neurons. In order to reconnect, the neurons need to be stimulated through activity.

Neuroplasticity sometimes may also contribute to impairment. For example, people who are deaf may suffer from a continual ringing in their ears (**tinnitus**), the result of the rewiring of brain cells starved for sound. For neurons to form beneficial connections, they must be correctly stimulated.

Neuroplasticity is also called brain plasticity or brain malleability.

Types Of Cortical Neuroplasticity

Developmental plasticity occurs most profoundly in the first few years of life as neurons grow very rapidly and send out multiple branches, ultimately forming too many connections. In fact, at birth, each neuron in the cerebral cortex (the highly convoluted outer layer

of the cerebrum) has about 2,500 synapses. By the time an infant is two or three years old, the number of synapses is approximately 15,000 per neuron. This amount is about twice that of the average adult brain. The connections that are not reinforced by sensory stimulation eventually weaken, and the connections that are reinforced become stronger. Eventually, efficient pathways of neural connections are carved out.

Throughout the life of a human or other mammal, these neural connections are fine-tuned through the organism's interaction with its surroundings. During early childhood, which is known as a critical period of development, the nervous system must receive certain sensory inputs in order to develop properly.

Once such a critical period ends, there is a precipitous drop in the number of connections that are maintained, and the ones that do remain are the ones that have been strengthened by the appropriate sensory experiences. This massive "pruning back" of excess synapses often occurs during adolescence.

Homologous area adaptation

Homologous area adaptation occurs during the early critical period of development. If a particular brain module becomes damaged in early life, its normal operations have the ability to shift to brain areas that do not include the affected module. The function is often shifted to a module in the matching, or homologous, area of the opposite brain hemisphere. The downside to this form of neuroplasticity is that it may come at costs to functions that are normally stored in the module but now have to make room for the new functions. An example of this is when the right parietal lobe (the parietal lobe forms the middle region of the cerebral hemispheres) becomes damaged early in life and the left parietal lobe takes over

visuospatial functions at the cost of impaired arithmetical functions, which the left parietal lobe usually carries out exclusively. Timing is also a factor in this process, since a child learns how to navigate physical space before he or she learns arithmetic.

Compensatory masquerade

The second type of neuroplasticity, compensatory masquerade, can simply be described as the brain figuring out an alternative strategy for carrying out a task when the initial strategy cannot be followed due to impairment. One example is when a person attempts to navigate from one location to another. Most people, to a greater or lesser extent, have an intuitive sense of direction and distance that they employ for navigation. However, a person who suffers some form of brain trauma and impaired spatial sense will resort to another strategy for spatial navigation, such as memorizing landmarks. The only change that occurs in the brain is a reorganization of preexisting neuronal networks.

Cross-modal reassignment

The third form of neuroplasticity, cross-modal reassignment, entails the introduction of new inputs into a brain area deprived of its main inputs. A classic example of this is the ability of an adult who has been blind since birth to have touch, or somatosensory, input redirected to the visual cortex in the occipital lobe (region of the cerebrum located at the back of the head) of the brain—specifically, in an area known as V1. Sighted people, however, do not display any V1 activity when presented with similar touch-oriented experiments. This occurs because neurons communicate with one another in the same abstract “language” of electrochemical impulses regardless of sensory modality. Moreover, all the sensory cortices of the brain—visual, auditory, olfactory (smell, gustatory

(taste and somatosensory—have a similar six-layer processing structure. Because of this, the visual cortices of blind people can still carry out the cognitive functions of creating representations of the physical world but base these representations on input from another sense—namely, touch. This is not, however, simply an instance of one area of the brain compensating for a lack of vision. It is a change in the actual functional assignment of a local brain region.

Map expansion

Map expansion, the fourth type of neuroplasticity, entails the flexibility of local brain regions that are dedicated to performing one type of function or storing a particular form of information. The arrangement of these local regions in the cerebral cortex is referred to as a "map." When one function is carried out frequently enough through repeated behaviour or stimulus, the region of the cortical map dedicated to this function grows and shrinks as an individual "exercises" this function. This phenomenon usually takes place during the learning and practicing of a skill such as playing a musical instrument. Specifically, the region grows as the individual gains implicit familiarity with the skill and then shrinks to baseline once the learning becomes explicit. (Implicit learning is the passive acquisition of knowledge through exposure to information, whereas explicit learning is the active acquisition of knowledge gained by consciously seeking out information.) But as one continues to develop the skill over repeated practice, the region retains the initial enlargement.

Map expansion neuroplasticity has also been observed in association with pain in the phenomenon of phantom limb syndrome. The relationship between cortical reorganization and phantom limb pain was discovered in the 1990s in arm amputees. Later studies indicated that in amputees who experience phantom

limb pain, the mouth brain map shifts to take over the adjacent area of the arm and hand brain maps. In some patients, the cortical changes could be reversed with peripheral anesthesia.

What is Methods of Physiological Psychology: Invasive methods – Anatomical methods, degeneration techniques, lesion techniques, chemical methods, microelectrode studies. Non-invasive methods – EEG, Scanning methods?

Methods of Physiological Psychology: Invasive methods – Anatomical methods, degeneration techniques, lesion techniques, chemical methods, microelectrode studies. Non-invasive methods – EEG, Scanning methods

Methods of Physiological Psychology: Invasive methods

As a generally noninvasive subset of neuroscience methods, psychophysiological methods are used across a variety of disciplines in order to answer diverse questions about psychology, both mental events and behavior. Many different techniques are classified as psychophysiological. Each technique has its strengths and weaknesses, and knowing them allows researchers to decide what each offers for a particular question. Additionally, this

knowledge allows research consumers to evaluate the meaning of the results in a particular experiment.

Learning Objectives

- Learn what qualifies as psychophysiology within the broader field of neuroscience.
- Review and compare several examples of psychophysiological methods.
- Understand advantages and disadvantages of different psychophysiological methods.

History

In the mid-19th century, a railroad worker named Phineas Gage was in charge of setting explosive charges for blasting through rock in order to prepare a path for railroad tracks. He would lay the charge in a hole drilled into the rock, place a fuse and sand on top of the charge, and pack it all down using a tamping iron (a solid iron rod approximately one yard long and a little over an inch in diameter). On a September afternoon when Gage was performing this task, his tamping iron caused a spark that set off the explosive prematurely, sending the tamping iron flying through the air.

Unfortunately for Gage, his head was above the hole and the tamping iron entered the side of his face, passed behind his left eye, and exited out of the top of his head, eventually landing 80 feet away. Gage lost a portion of his left frontal lobe in the accident, but survived and lived for another 12 years. What is most interesting from a psychological perspective is that Gage's personality changed as a result of this accident. He became more impulsive, he had trouble carrying out plans, and, at times, he engaged in vulgar profanity, which was out of character. This case study leads one to

believe that there are specific areas of the brain that are associated with certain psychological phenomena. When studying psychology, the brain is indeed an interesting source of information. Although it would be impossible to replicate the type of damage done to Gage in the name of research, methods have developed over the years that are able to safely measure different aspects of nervous system activity in order to help researchers better understand psychology as well as the relationship between psychology and biology.

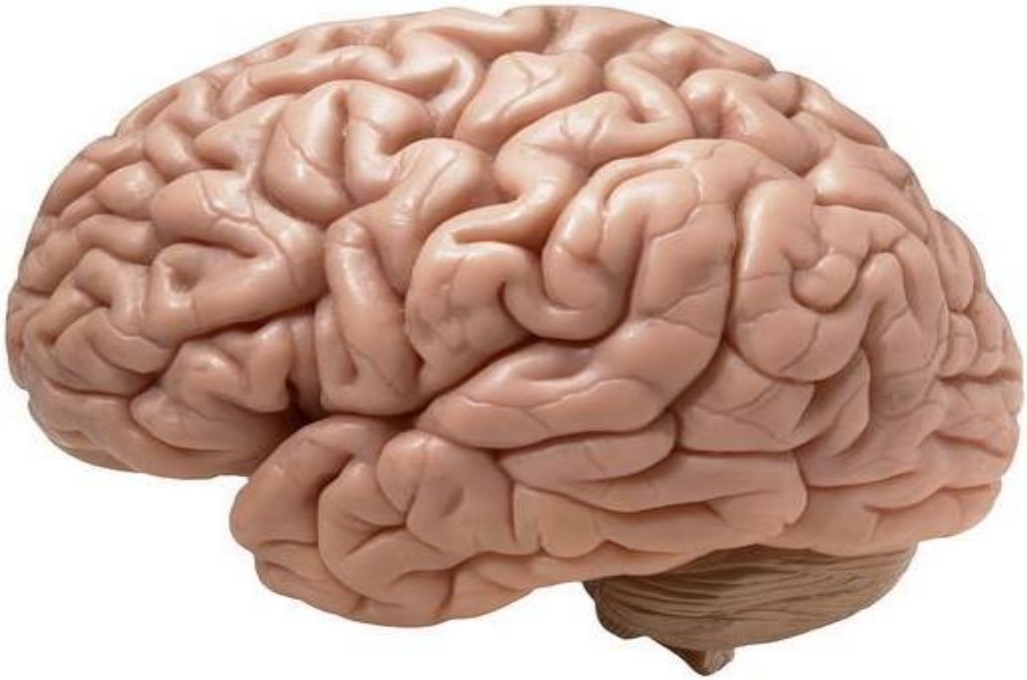
Introduction

Psychophysiology is defined as any research in which the dependent variable (what the researcher measures) is a physiological measure, and the independent variable (what the researcher manipulates) is behavioral or mental. In most cases the work is done noninvasively with awake human participants. Physiological measures take many forms and range from blood flow or neural activity in the brain to heart rate variability and eye movements. These measures can provide information about processes including emotion, cognition, and the interactions between them. In these ways, physiological measures offer a very flexible set of tools for researchers to answer questions about behavior, cognition, and health.

Psychophysiological methods are a subset of the very large domain of **neuroscience methods**. Many neuroscience methods are **invasive**, such as involving **lesions** of neural tissue, injection of neutrally active chemicals, or manipulation of neural activity via electrical stimulation. The present survey emphasizes **noninvasive** methods widely used with human subjects.

Crucially, in examining the relationship between physiology and overt behavior or mental events, psychophysiology does not attempt to replace the latter with the former. As an example, happiness is a state of pleasurable contentment and is associated with various physiological measures, but one would not say that those physiological measures are happiness. We can make inferences about someone's cognitive or emotional state based on his or her self-report, physiology, or overt behavior. Sometimes our interest is primarily in inferences about internal events and sometimes primarily in the physiology itself. Psychophysiology addresses both kinds of goals.

Central Nervous System (CNS)



The adult human brain only makes up about 2% (i.e. ≈ 3 pounds) of the average adult's weight, but it uses 20% of the body's energy!

[Image: _DJ_, https://goo.gl/eHPH5L, CC BY-SA 2.0, https://goo.gl/rxiUsF]

This module provides an overview of several popular psychophysiological methods, though it is far from exhaustive. Each method can draw from a broad range of data-analysis strategies to provide an even more expansive set of tools. The psychophysiological methods discussed below focus on the central nervous system. Structural magnetic resonance imaging (sMRI) is a noninvasive technique that allows researchers and clinicians to view anatomical structures within a human. The participant is placed in a magnetic field that may be 66,000 times greater than the Earth's magnetic field, which causes a small portion of the atoms in his or her body to line up in the same direction. The body is then pulsed with low-energy radio frequencies that are absorbed by the atoms in the body, causing them to tip over.

As these atoms return to their aligned state, they give off energy in the form of harmless electromagnetic radiation, which is measured by the machine. The machine then transforms the measured energy into a three-dimensional picture of the tissue within the body. In psychophysiology research, this image may be used to compare the size of structures in different groups of people (e.g., are areas associated with pleasure smaller in individuals with depression?) or to increase the accuracy of spatial locations as measured with functional magnetic resonance imaging (fMRI).

Peripheral Nervous System

The psychophysiological methods discussed above focus on the central nervous system. Considerable research has also focused on the **peripheral nervous system**. These methods include skin conductance, cardiovascular responses, muscle activity, pupil

diameter, eye blinks, and eye movements. Skin conductance, for example, measures the electrical conductance (the inverse of resistance) between two points on the skin, which varies with the level of moisture. Sweat glands are responsible for this moisture and are controlled by the **sympathetic nervous system (SNS)**. Increases in skin conductance can be associated with changes in psychological activity. For example, studying skin conductance allows a researcher to investigate whether psychopaths react to fearful pictures in a normal way. Skin conductance provides relatively poor temporal resolution, with the entire response typically taking several seconds to emerge and resolve. However, it is an easy way to measure SNS response to a variety of stimuli.

Cardiovascular measures include heart rate, heart rate variability, and blood pressure. The heart is innervated by the **parasympathetic nervous system (PNS)** and SNS. Input from the PNS decreases heart rate and contractile strength, whereas input from the SNS increases heart rate and contractile strength. Heart rate can easily be monitored using a minimum of two electrodes and is measured by counting the number of heartbeats in a given time period, such as one minute, or by assessing the time between successive heartbeats. Psychological activity can prompt increases and decreases in heart rate, often in less than a second, making heart rate a sensitive measure of cognition.

In recent years a wide range of experimental methods has become available to advance the understanding of the structure and function of human auditory cortex. Among the noninvasive approaches are electroencephalography (EEG) and magnetoencephalography (MEG), which record cortical activity at a distance using electrodes glued to the scalp or from sensors distributed around the head, and brain-imaging methods based on changes in cerebral blood fl ow,

including positron emission tomography (PET) and functional magnetic resonance imaging (fMRI. Invasive approaches involve electrophysiological recording from and electrically stimulating or locally cooling cortex directly, usually in neurosurgical patients undergoing diagnosis and treatment of medically intractable epilepsy.

Brief Historic Overview

Progress in invasive human brain research has paralleled advances in the fi eld of functional neurosurgery, electronic engineering, computer technology, and signal processing. Although technical aspects of invasive human brain research have changed markedly over the years, the importance of a multidisciplinary research team, pioneered by neurosurgeon Wilder Penfi eld, has remained. Today,

research of this kind draws heavily on the disciplines of anatomy, physiology, psychophysics, neuropsychology, radiology, theoretical modeling, statistics, acoustics, signal processing, electronic engineering, and computer programming.

With the awake patient's brain exposed, Penfi eld and his team carefully recorded bodily movements and verbal reports of sensations evoked by an electrical stimulus delivered to a cortical site through a hand-held stimulator. The anatomical location of each stimulated cortical locus was documented on a highresolution intraoperative photograph of the brain surface. The results provided the fi rst direct, systematic evidence of how human cerebral cortex is functionally organized.

Contemporary Research

Research Subjects

Invasive studies of auditory cortex in humans are carried out in neurosurgical patients, the vast majority of whom are being treated for medically intractable epilepsy. Epilepsy is a common neurological disorder that affects approximately 50 million people worldwide (World Health Organization, 2005) .

These individuals are at risk of losing consciousness suddenly and without warning and thus often are unable to operate a motor vehicle or hold a job that requires sustained vigilance and attention. There is also evidence that persistent seizure activity may lead to structural brain damage (Bonilha et al., 2006 ; Bernhardt et al., 2009) . It is estimated that in the United States alone, more than 400,000 individuals with epilepsy continue to have seizures despite receiving appropriate medical treatment (Engel, 2001)

. A subset of this medically refractory patient population can be treated effectively with surgery that removes brain tissue that is the source of the seizure activity.

These patients also are ideal subjects for invasive brain research. Third, their seizure focus must be localized to a circumscribed portion of the brain that can be safely removed surgically. Making this latter determination is the most challenging aspect of the presurgical evaluation process, which includes EEG recording, anatomical magnetic resonance imaging (MRI), and formal neuropsychological testing. The patient's history and test data are discussed at a multidisciplinary epilepsy surgery conference where a consensus is sought regarding whether the patient is a candidate for surgery, and, if so, the type of operation that should be performed. Surgical patients then wishing to participate in research are given a detailed explanation of the planned research protocols and provide informed consent before becoming a "research subject" and undergoing additional "research only" preoperative testing.

Validity of Invasive Recordings

Although these invasive studies are intended to provide insights into the functional organization of normal human auditory cortex, interpreting the results obtained is done within the context of repeated seizure activity experienced by the study patients, often over periods of years, as well as the present and long-term use of multiple antiepileptic drugs.

Surgical patients serving as research subjects are only those diagnosed with a focal seizure disorder. The seizure focus is typically localized to the mesial portion of the temporal lobe, including the hippocampus, where anatomical malformations have been well documented in individuals with drug resistant temporal lobe epilepsy (Gloor, 1991) . Thalamic atrophy is reported to be most intense in thalamic nuclei having strong connections with limbic structures(Bonilha et al., 2006) .

Epileptic discharges that occasionally invade cortex under study from a distant seizure focus are routinely detected and excluded from analyses. There is also evidence that in addition to mesial temporal malformations there is progressive atrophy of temporopolar, orbitofrontal, insular, and parietal areas (Bernhardt et al., 2009) as well as widespread thinning of neocortex, including lateral temporal regions (Bonilha et al., 2006 ; Bernhardt et al., 2010) that are considered to be auditory or auditory-related cortex. Thus, one cannot rule out the possibility that pathological processes associated with seizure disorders infl uence activity recording from distant cortical sites.

We also note, however, that data obtained from the auditory core in particular bear a striking resemblance to those recorded from core cortex in the monkey (Fishman et al., 2001 ; Steinschneider et al.,

2005 ; Ray et al., 2008 ; Brugge et al., 2009), suggesting that functional organization and certain stimulus–response relationships found in this area have been relatively spared.

Summary

The methodology of invasive research of human auditory cortex has made tremendous progress since the early studies of Penfi eld and his colleagues. These developments have paralleled the strides made in developing noninvasive imaging and electrophysiological recording methods. By employing invasive and noninvasive approaches in complementary ways to studies of the functional organization of auditory cortex, the knowledge gained promises to be far greater than that obtainable by relying on any one method alone. Despite advances, however, technical shortcomings continue to impose limitations on invasive cortical electrophysiological recording and stimulation as research tools.

Chronically implanted electrode arrays are tethered to head-mounted connectors that are, in turn, connected to external electronic instruments. Current data acquisition systems and surgical techniques allow for extensive (>200 contacts) electrode coverage making the external cables bulky and sometimes uncomfortable for the patient. External electrical (power line) noise easily coupled to wires often introduces unwanted interference during recording sessions.

Wires can, and do, break, especially during seizures, resulting in loss of both clinical and research data. All of these considerations have a direct impact on the conduct and outcome of research, which in turn relate directly to patient safety and successful diagnosis of brain disorders and to successful development of neural prostheses.

Anatomical methods

Anatomy / Physiological Function

X-ray picture.

CAT scanning was invented in 1972 by the British engineer Godfrey N. Hounsfield and the South African (later American) physicist Alan Cromack.

CAT (Computed Axial Tomography) is an x-ray procedure which combines many x-ray images with the aid of a computer to generate cross-sectional views, and when needed 3D images of the internal organs and structures of the human body. A large donut-shaped x-ray machine takes x-ray images at many different angles around the body. Those images are processed by a computer to produce cross-sectional picture of the body. In each of these pictures the body is seen as an x-ray 'slice' of the body, which is recorded on a film. This recorded image is called a tomogram.

CAT scans are performed to analyze, for example, the head, where traumatic injuries (such as blood clots or skull fractures), tumors, and infections can be identified. In the spine the bony structure of the vertebrae can be accurately defined, as can the anatomy of the spinal cord. CAT scans are also extremely helpful in defining body organ anatomy, including visualizing the liver, gallbladder, pancreas, spleen, aorta, kidneys, uterus, and ovaries. The amount of radiation a person receives during a CAT scan is minimal. In men and non-pregnant women it has not been shown to produce any adverse effects. However, doing a CAT test hides some risks. If the subject or the patient is pregnant it maybe recommended to do another type of exam to reduce the possible risk of exposing her fetus to radiation. Also in cases of asthma or allergies it is recommended to avoid this type of scanning. Since the CAT scan

requires a contrast medium, there's a slight risk of an allergic reaction to the contrast medium. Having certain medical conditions; Diabetes, asthma, heart disease, kidney problems or thyroid conditions also increases the risk of a reaction to contrast medium.

MRI

Although CAT scanning was a breakthrough, in many cases it was substituted by magnetic resonance imaging (MRI), a method of looking inside the body without using x-rays, harmful dyes or surgery. Instead, radio waves and a strong magnetic field are used in order to provide remarkably clear and detailed pictures of internal organs and tissues.

MRI head side

History and Development of MRI

MRI is based on a physics phenomenon called nuclear magnetic resonance (NMR), which was discovered in the 1930s by Felix Bloch (working at Stanford University) and Edward Purcell (from Harvard University). In this resonance, magnetic field and radio waves cause atoms to give off tiny radio signals. In the year 1970, Raymond Damadian, a medical doctor and research scientist, discovered the basis for using magnetic resonance imaging as a tool for medical diagnosis. Four years later a patent was granted, which was the world's first patent issued in the field of MRI. In 1977, Dr. Damadian completed the construction of the first “whole-body” MRI scanner, which he called the ”Indomitable”. The medical use of magnetic resonance imaging has developed rapidly. The first MRI equipment in healthcare was available at the beginning of the 1980s. In 2002, approximately 22,000 MRI scanners were in use

worldwide, and more than 60 million MRI examinations were performed.

A full size MRI-Scanner

Common Uses of the MRI Procedure

Because of its detailed and clear pictures, MRI is widely used to diagnose sports-related injuries, especially those affecting the knee, elbow, shoulder, hip and wrist. Furthermore, MRI of the heart, aorta and blood vessels is a fast, non-invasive tool for diagnosing artery disease and heart problems. The doctors can even examine the size of the heart-chambers and determine the extent of damage caused by a heart disease or a heart attack. Organs like lungs, liver or spleen can also be examined in high detail with MRI. Because no radiation exposure is involved, MRI is often the preferred diagnostic tool for examination of the male and female reproductive systems, pelvis and hips and the bladder.

Risks

An undetected metal implant may be affected by the strong magnetic field. MRI is generally avoided in the first 12 weeks of pregnancy. Scientists usually use other methods of imaging, such as ultrasound, on pregnant women unless there is a strong medical reason to use MRI.

PPT MRIII

Reconstruction of nerve fibers

There has been some further development of the MRI: The DT-MRI (diffusion tensor magnetic resonance imaging) enables the measurement of the restricted diffusion of water in tissue and gives a 3-dimensional image of it. History: The principle of using a

magnetic field to measure diffusion was already described in 1965 by the chemist Edward O. Stejskal and John E. Tanner. After the development of the MRI, Michael Moseley introduced the principle into MR Imaging in 1984 and further fundamental work was done by Dennis LeBihan in 1985. In 1994 the engineer Peter J. Basser published optimized mathematical models of an older diffusion-tensor model This model is commonly used today and supported by all new MRI-devices.

The DT-MRI technique takes advantage of the fact that the mobility of water molecules in brain tissue is restricted by obstacles like cell membranes. In nerve fibers mobility is only possible alongside the axons. So measuring the diffusion gives rise to the course of the main nerve fibers. All the data of one diffusion-tensor are too much to process in a single image, so there are different techniques for visualization of different aspects of this data: - Cross section images - tractography (reconstruction of main nerve fibers) - tensor glyphs (complete illustration of diffusion-tensor information)

The diffusion manner changes by patients with specific diseases of the central nervous system in a characteristic way, so they can be discerned by the diffusion-tensor technique. Diagnosis of apoplectic strokes and medical research of diseases involving changes of the white matter, like Alzheimer's disease or Multiple sclerosis are the main applications. Disadvantages of DT-MRI are that it is far more time consuming than ordinary MRI and produces large amounts of data, which first have to be visualized by the different methods to be interpreted.

fMRI

The fMRI (Functional Magnetic Resonance) Imaging is based on the Nuclear magnetic resonance (NMR). The way this method

works is the following: All atomic nuclei with an odd number of protons have a nuclear spin. A strong magnetic field is put around the tested object which aligns all spins parallel or antiparallel to it. There is a resonance to an oscillating magnetic field at a specific frequency, which can be computed in dependence on the atom type (the nuclei's usual spin is disturbed, which induces a voltage s (t), afterwards they return to the equilibrium state). At this level different tissues can be identified, but there is no information about their location. Consequently the magnetic field's strength is gradually changed, thereby there is a correspondence between frequency and location and with the help of Fourier analysis we can get one-dimensional location information. Combining several such methods as the Fourier analysis it is possible to get a 3D image.

fMRI picture

The central idea for fMRI is to look at the areas with increased blood flow. Hemoglobin disturbs the magnetic imaging, so areas with an increased blood oxygen level dependant (BOLD) can be identified. Higher BOLD signal intensities arise from decreases in the concentration of deoxygenated haemoglobin. An fMRI experiment usually lasts 1-2 hours. The subject will lie in the magnet and a particular form of stimulation will be set up and MRI images of the subject's brain are taken. In the first step a high resolution single scan is taken. This is used later as a background for highlighting the brain areas which were activated by the stimulus. In the next step a series of low resolution scans are taken over time, for example, 150 scans, one every 5 seconds. For some of these scans, the stimulus will be presented, and for some of the scans, the stimulus will be absent. The low resolution brain images in the two cases can be compared, to see which parts of the brain were activated by the stimulus. The rest of the analysis is done using a series of tools

which correct distortions in the images, remove the effect of the subject moving their head during the experiment, and compare the low resolution images taken when the stimulus was off with those taken when it was on. The final statistical image shows up bright in those parts of the brain which were activated by this experiment. These activated areas are then shown as coloured blobs on top of the original high resolution scan. This image can also be rendered in 3D.

fMRI has moderately good spatial resolution and bad temporal resolution since one fMRI frame is about 2 seconds long. However, the temporal response of the blood supply, which is the basis of fMRI, is poor relative to the electrical signals that define neuronal communication. Therefore, some research groups are working around this issue by combining fMRI with data collection techniques such as electroencephalography (EEG) or magneto encephalography (MEG), which has much higher temporal resolution but rather poorer spatial resolution.

PET

Positron emission tomography, also called PET imaging or a PET scan, is a diagnostic examination that involves the acquisition of physiologic images based on the detection of radiation from the emission of positrons. It is currently the most effective way to check for cancer recurrences. Positrons are tiny particles emitted from a radioactive substance administered to the patient. This radiopharmaceutical is injected to the patient and its emissions are measured by a PET scanner. A PET scanner consists of an array of detectors that surround the patient. Using the gamma ray signals given off by the injected radionuclide, PET measures the amount of metabolic activity at a site in the body and a computer reassembles the signals into images. PET's ability to measure metabolism is very

useful in diagnosing Altsheimer's disease, Parkinson's disease, epilepsy and other neurological conditions, because it can precisely illustrate areas where brain activity differs from the norm. It is also one of the most accurate methods available to localize areas of the brain causing epileptic seizures and to determine if surgery is a treatment option. PET is often used in conjunction with an MRI or CT scan through "fusion" to give a full three-dimensional view of an organ.

Degeneration techniques

The hippocampus was stimulated with sufficient voltage to produce four negative peaks in a response wave recorded from the dorsal septum. The peaks had latencies of 5, 12, 25 and 50 msec, respectively. Transection of the fornix body with a scalpel eliminated the entire wave complex. Removal by suction of the postsplenial gyrus, gyrus cinguli and olfactory tubercle had little or no effect on the wave complex. Bilateral electrolytic coagulation of the anterior thalamic nuclei did not affect the wave complex.

Suction removal of the suprasylvian and ectosylvian gyri eliminated the long latency responses. Following lesions in the septum and body of the fornix, degeneration was observed in the fornix longus, the ventral surface of the corpus callosum and the corona radiata.

Terminals were observed in the suprasylvian and ectosylvian gyri. Small cautery lesions in these gyri resulted in degeneration in the contralateral ectosylvian gyrus, fornix longus, body and columns of the fornix, hippocampus, mamillary body and thalamus. Degeneration including terminals was also seen in other limbic structures. We conclude that the hippocampus, in addition to its

direct connections to the septum, has indirect projection to the septum via the suprasylvian and ectosylvian gyri.

The corticipetal connections are perhaps collaterals of other direct projection targets of the hippocampus to the septum, mamillary body, and anterior nuclei. Direct corticifugal connections to the septum, hippocampus and other structures are collaterals from direct contralateral corticocortical projections of the suprasylvian and ectosylvian gyri. Such connections perhaps influence overt behavior by mediating secondary cues; or exert an influence on drive mechanisms through the posterior hypothalmus.

Lesion method

In the lesion method, patients with brain damage are examined to determine which brain structures are damaged and how this influences the patient's behavior. Researchers attempt to correlate a specific brain area to an observed behavior by using reported experiences and research observations. Researchers may conclude that the loss of functionality in a brain region causes behavioral changes or deficits in task performance. For example, a patient with a lesion in the parietal-temporal-occipital association area will exhibit agraphia, a condition in which he/she is not able to write, despite having no deficits in motor ability. If damage to a particular brain region (structure X) is shown to correlate with a specific change in behavior (behavior Y), researchers may deduce that structure X has a relation to behavior Y.

In humans, lesions are most often caused by tumors or strokes. Through current brain imaging technologies, it is possible to determine which area was damaged during a stroke. Loss of function in the stroke victim may then be correlated with that damaged brain area. While lesion studies in humans have provided

key insights into brain organization and function, lesions studies in animals offer many advantages.

First, animals used in research are reared in controlled environmental conditions that limit variability between subjects. Secondly, researchers are able to measure task performance in the same animal, before and after a lesion. This allows for within-subject comparison. And third the control groups can be watched who either did not undergo surgery or who did have surgery in another brain area. These benefits also increase the accuracy of the hypothesis being tested which is more difficult in human research because the before-after comparison and control experiments drop out.

Visualization of iron rod passing through brain of Phineas Gage

To strengthen conclusions regarding a brain area and task performance, researchers may perform double dissociation. The goal of this method is to prove that two dissociations are independent. Through comparison of two patients with differing brain damage and contradictory disease patterns, researchers may localize different behaviors to each brain area. Broca's area is a region of the brain is responsible for language processing, comprehension and speech production. Patients with a lesion in Broca's area will exhibit Broca's aphasia or non-fluent aphasia. These patients are unable to speak fluently; a sentence produced by a patient with damage to the Broca's area may sound like: "I ... er ... wanted ... ah ... well ... I ... wanted to ... er ... go surfing ... and ..er ... well...". On the other hand, Wernicke's area is responsible for speech comprehension. A patient with a lesion in this area has Wernicke's aphasia. They may be able to produce language,

but lack the ability to produce meaningful sentences. Patients may produce 'word salad': " I then did this chingo for some hours after my dazi went through meek and been sharko". Patients with Wernicke's aphasia are often unaware of speech deficits and may believe that they are speaking properly.

Certainly one of the famous "lesion" cases was that of Phineas Gage. On 13 September 1848 Gage, a railroad construction foreman, was using an iron rod to tamp an explosive charge into a body of rock when premature explosion of the charge blew the rod through his left jaw and out the top of his head. Miraculously,

Gage survived, but reportedly underwent a dramatic personality change as a result of destruction of one or both of his frontal lobes. The uniqueness of Gage case (and the ethical impossibility of repeating the treatment in other patients) makes it difficult to draw generalizations from it, but it does illustrate the core idea behind the lesion method. Further problems stem from the persistent distortions in published accounts of Gage—see the Wikipedia article Phineas Gage.

Chemical methods

Lesion method

In the lesion method, patients with brain damage are examined to determine which brain structures are damaged and how this influences the patient's behavior. Researchers attempt to correlate a specific brain area to an observed behavior by using reported experiences and research observations. Researchers may conclude that the loss of functionality in a brain region causes behavioral changes or deficits in task performance. For example, a patient with a lesion in the parietal-temporal-occipital association area will exhibit agraphia a condition in which he/she is not able to write,

despite having no deficits in motor ability. If damage to a particular brain region (structure X) is shown to correlate with a specific change in behavior (behavior Y), researchers may deduce that structure X has a relation to behavior Y.

In humans, lesions are most often caused by tumors or strokes. Through current brain imaging technologies, it is possible to determine which area was damaged during a stroke. Loss of function in the stroke victim may then be correlated with that damaged brain area. While lesion studies in humans have provided key insights into brain organization and function, lesions studies in animals offer many advantages.

First, animals used in research are reared in controlled environmental conditions that limit variability between subjects. Secondly, researchers are able to measure task performance in the same animal, before and after a lesion. This allows for within-subject comparison. And third the control groups can be watched who either did not undergo surgery or who did have surgery in another brain area. These benefits also increase the accuracy of the hypothesis being tested which is more difficult in human research because the before-after comparison and control experiments drop out.

Visualization of iron rod passing through brain of Phineas Gage

To strengthen conclusions regarding a brain area and task performance, researchers may perform double dissociation. The goal of this method is to prove that two dissociations are independent. Through comparison of two patients with differing brain damage and contradictory disease patterns, researchers may localize different behaviors to each brain area. Broca's area is a

region of the brain is responsible for language processing, comprehension and speech production. Patients with a lesion in Broca's area will exhibit Broca's aphasia or non-fluent aphasia. These patients are unable to speak fluently; a sentence produced by a patient with damage to the Broca's area may sound like: "I ... er ... wanted ... ah ... well ... I ... wanted to ... er ... go surfing ... and ..er ... well...". On the other hand, Wernicke's area is responsible for speech comprehension. A patient with a lesion in this area has Wernicke's aphasia. They may be able to produce language, but lack the ability to produce meaningful sentences. Patients may produce 'word salad': " I then did this chingo for some hours after my dazi went through meek and been sharko". Patients with Wernicke's aphasia are often unaware of speech deficits and may believe that they are speaking properly.

Certainly one of the famous "lesion" cases was that of Phineas Gage. On 13 September 1848 Gage, a railroad construction foreman, was using an iron rod to tamp an explosive charge into a body of rock when premature explosion of the charge blew the rod through his left jaw and out the top of his head. Miraculously, Gage survived, but reportedly underwent a dramatic personality change as a result of destruction of one or both of his frontal lobes. The uniqueness of Gage case (and the ethical impossibility of repeating the treatment in other patients) makes it difficult to draw generalizations from it, but it does illustrate the core idea behind the lesion method. Further problems stem from the persistent distortions in published accounts of Gage—see the Wikipedia article Phineas Gage.

• Most commonly used technique today.

• Instead of an electrode, use a cannula or tube.

• Allows you to place chemicals in place where they can kill or influence neurons.

Neurotoxins

• 6 Hydroxydopamine (6HDA)

• Destroys dopamine neurons but leaves other neurons alone.

• Advantage: Allows you to only kill one type of neuron.

• Kanic Acid • Destroys somas (cell bodies) of neurons, but leaves axon tracts from other neurons alone.

Advantage:

Can kill neurons in one area, but does not disturb neuron tracts from other areasChemical Stimulation Techniques.

• Are the opposite of chemical lesioning

• Researcher may stimulate neurons by putting in a neurotransmitter.

• May also put in agonists (analogs of neurotransmitters that behave like them).

• May put in compounds with unknown effects.

General Cannulation Procedures

• Make a trephine hole.

• Insert cannula with stereotaxic device.

• Cement in place with dental cement.

• Allow animal to recover and behave normally.

• Later, deliver compound by injection (usually when the animal is behaving).

• Observe the animal.

Disadvantage

• Over time the area fills up with the chemical.

• Solution: Use a push-pull technique.

Microelectrode studies

Microelectrodes are electrodes with tip areas of the order of micrometers, i.e., so small that they do not induce significant damage in the sample to be tested. Such requirements are especially important in living tissue, where microelectrodes have found their widest application; for intracellular recordings tip diameters less than 1 μm are required. Microelectrodes can also be used in combination with recent techniques of molecular biology.

Microelectrodes are basically of four types: glass micropipettes, ion-selective microelectrodes, solid-state microelectrodes, and enzyme microelectrodes (Figure 1). Glass micropipettes are used to record steady-state (DC) and alternating (AC) electrical potentials. If the glass micropipette is plugged with an ion-selective membrane, the microelectrode will record a potential that is proportional to the external activity of the ion to which the membrane is sensitive. Metal microelectrodes are well suited to recording AC potentials in situations where mechanical strength is required. Metal microelectrodes can also be used for cyclic voltammetry or amperometry purposes. If a metal microelectrode made from an inert metal or carbon is maintained at

a given potential, the current can only pass the solution–electrode interphase if electrons can be provided or taken up by the chemical processes at the electrode surface. In cyclic voltammetry the voltage between the metal microelectrode and the reference electrode is varied in a cyclical manner. The voltage at which current can flow and the magnitude of the currents will characterize the chemical composition of the external media. Ambient oxygen concentrations can be measured in this way as the current flow obtained at a voltage of 600 mV relative to an Ag/AgCl reference electrode. If the electrode is prepared with specific enzymes attached to the tip area, it can be used to record substrates that in themselves do not participate in redox processes, e.g., glucose.

Calcium in Living Cells

Microelectrode Pulling and Silanization

MEs can be prepared “on-demand” and in “batch” methods. The first method consists in preparing (i.e., pulling and silanizing) MEs on the experimental day, which has the obvious advantage of having “freshly” prepared electrodes and of being able to manufacture as many as desired a day. Protocols have been described (reviewed in Ammann, 1986). The batch method that we use consists of preparing a batch of MEs that can be kept for several days in a dry, dust-proof container.

MEs are pulled on a programmable horizontal stage puller (Model P80 PC or comparable, Sutter Instruments, USA). By trial-and-error, and according to the type of biological preparations studied, a satisfactory shape of ME can be found. However, several aspects of ME pulling have to be taken into account when designing its shape.

As ion-selective MEs have an intrinsically high resistance (i.e., > 50–100 GΩ), the signal-to-noise ratio has to be minimized. This

can be achieved in two ways: the first, and most obvious, is to increase the tip diameter, within certain limits, which are dictated by the size of the cell type. In our case, we impale cardiac cells in whole muscle. Cell length is typically between 50 and 150 μm and tip diameters less than 0.5 μm are needed. However, there is a trade-off between tip diameter and detection limit of the electrode (see below).

That is, increasing tip diameter improves electrode response (in terms of detection limit and speed of response), but is more likely to damage the cell during impalement. Another simple way to decrease the resistance is to decrease the length of the ME shank. This further helps to reduce capacitative artifacts, that are encountered when the level of physiological solution fluctuates in the experimental bath (Vaughan-Jones and Kaila, 1986), and also helps electrolyte filling (see below). In contracting muscular preparations, the shank should also possess some flexibility to avoid dislodging of the ME during a contraction.

Electrochemical arrays

Microelectrodes are employed to induce electrochemical reactions resulting in the production of an acid, which is required to iteratively deblock the 5′-DMTr groups of growing DNA chains (Egeland and Southern, 2005). The acid is produced only at specified sites by electrochemical oxidation of hydroquinone using individually addressable microelectrodes. As shown in Figure 12, the diffusion of the acid to its intended location on the DNA array is controlled by an adjacent cathode, which prevent the 5′-DMTr deblocking of neighboring sites by consuming any diffused acid.

Summary

MER has a long history in the experimental study and clinical treatment of movement disorders, particularly to delineate the anatomic relationships for targeting. MER offers a degree of precision unparalleled by any other implantation technology and can allow for correction of stereotactic targeting error and provide confirmation that the physiologic target has been identified. Improvements in imaging and stereotactic technology have mitigated some of these benefits, and MER may be associated with increased complexity and risk of complications without necessarily improving outcome. Although excellent outcomes have been reported with and without MER, a direct comparison has never been performed. With the advent of new technologies for intraoperative targeting, the role of MER in the stereotactic implantation of DBS electrodes is likely to continue to evolve.

Non-invasive methods – EEG

Researchers working on the field of **Neuroscience** have surely sometimes thought about this question. It might sound like Sci-Fi for the common laymen, but **neuro-implants** are a reality nowadays. In this post I would like to give an introduction to the different brain recording techniques and comment the pros and cons of **invasive vs. non-invasive recording techniques**.

An **electroencephalogram (EEG)** is the recording of the brain electrical activity. A set of electrodes are placed on the scalp of the subject. This technique is **non-invasive** since no surgery is required. **EEG** is a fast and cheap technique. The main drawback is that by recording the electrical activity far away from the source (i.e. the neurones inside the skull), the signal we pick up is distorted and

its amplitude reduced. Moreover **EEG** is often contaminated with artefacts.

The next technique in the increasing invasiveness scale is called **Electrocorticogram (ECoG)**. This technique requires opening the skull of the subject and placing an electrode array on the exposed brain. The quality of the signal (in terms of distortion and amplitude) is much better than **EEG**, but obviously surgery is required. In principle, this technique does not damage the brain, or at least not too much. It is often used in severe epileptic patients before undergoing surgery to localise the brain focus of the seizures.

The most invasive technique is called **deep brain recording**. In this case a **microelectrode** is placed deep inside the brain. This procedure destroys the neurones it finds in its way irreversibly. The advantage of this technique is that we can record signals from very well defined spatial locations. An important use of this technique, together with **deep brain stimulation** (i.e. rather than recording, you can also use the same electrodes to inject electrical currents), is in the treatment of Parkinson's disease patients. After stimulating deep brain areas, the patients greatly improve their motor skills.

A very interesting and popular application, the so-called **brain computer interface (BCI)**, uses brain activity to control external actuators. In order for a **BCI** to be reliable, we need a reliable brain recording.

Key Points

- Neuroimaging, or brain scanning, includes the use of various techniques to either directly or indirectly image the structure, function, or pharmacology of the brain.

- Neuroimaging falls into two broad categories: structural imaging and functional imaging.
- Electroencephalography (EEG) is used to show brain activity under certain psychological states, such as alertness or drowsiness.
- Positron emission tomography (PET) scans show brain processes by using the sugar glucose in the brain to illustrate where neurons are firing.
- Magnetic resonance imaging (MRI) scans use echo waves to discriminate among grey matter, white matter, and cerebrospinal fluid.
- Functional magnetic resonance imaging (fMRI) scans are a series of MRIs measuring brain function via a computer's combination of multiple images taken less than a second apart.

Key Terms

- **conductivity**: The ability of a material to conduct electricity, heat, fluid, or sound.
- **magnetic field**: A condition in the space around a magnet or electric current in which there is a detectable magnetic force and two magnetic poles are present.

Neuroimaging falls into two broad categories:

1. Structural imaging, which deals with the structure of the brain and the diagnosis of large-scale intracranial disease (such as a tumor), as well as injury.

2. Functional imaging, which is used to diagnose metabolic diseases and lesions on a finer scale (such as Alzheimer's disease), and also for neurological and cognitive-psychology research. Functional imaging allows the brain's information processing to be visualized directly, because activity in the involved area of the brain increases metabolism and "lights up" on the scan.

Four of the most common types of brain scans are EEG, PET, MRI, and fMRI.

Electroencephalography (EEG)

Electroencephalography (EEG) is used to show brain activity in certain psychological states, such as alertness or drowsiness. It is useful in the diagnosis of seizures and other medical problems that involve an overabundance or lack of activity in certain parts of the brain.

To prepare for an EEG, electrodes are placed on the face and scalp. After placing each electrode in the right position, the electrical potential of each electrode can be measured. According to a person's state (waking, sleeping, etc.), both the frequency and the form of the EEG signal differ. Patients who suffer from epilepsy show an increase of the amplitude of firing visible on the EEG record. The disadvantage of EEG is that the electric conductivity — and therefore the measured electrical potentials—may vary widely from person to person and also over time, due to the natural conductivities of other tissues such as brain matter, blood, and bones. Because of this, it is sometimes unclear exactly which region of the brain is emitting a signal.

Scanning methods

Introduction

The analytical operation of miniaturized voltammetric sensors above, at, and inside cultured or isolated living cells, living cell clusters and macro- or microstructures of immobilized bio-(macro-)molecules for sensitive local determination of biological activity is a unique strategy across disciplines. The aim is to inspect, on a fundamental level, physiological, pathological and molecular life science phenomena with high spatial and temporal resolution. The output of the bioanalysis using micro- and nanoelectrode voltammetry is data and knowledge generation in support of advancements in modern personal healthcare, drug development and nutrition, all issues that are more than ever before acute for an increasingly ageing global society. Examples of foundational explorations of the tailored bioelectroanalytical methodology are the 1969 analyses of oxygen profiles in and above microbial slime and the 1973 initiation of voltammetry in brain tissue with the sensitive tips made of metal and carbon, respectively. The two decades later, the move to, for instance, electrochemical detection of distinct biological processes of chemical neurotransmission at the level of single living cells and single-vesicle exocytosis was the logical result of the accomplishment of continuous sensor and apparatus improvements. This was driven by the scientific desire and methodical necessity to extend investigations into the function of biological entities to actions within or at the smallest complete building blocks of living organisms. Selection of target cells and sensor tip positioning at or in close proximity to their membranes were initially performed in conventional electrophysiology set-ups with inverted microscopes employed for cell visualization and manually operated three-dimensional micropositioning devices used

for voltammetric sensor and/or culture plate movement. However, at approximately the same time as the progression of single cell voltammetry, the invention of scanning electrochemical microscopy (SECM) occurred and the novel scanning probe system became rather quickly a favoured complementary analytical platform for the inspection and visualization of cellular activities.

In a scanning electrochemical microscope, a scanning electrochemical probe (SECM tip) is a sensitive collector of redox species as the basis of a faradaic current signal that depends on both the distance to the sample and the absence or presence of sample surface redox activity. Careful computer-controlled movement across a sample of interest and acquisition of localized SECM tip currents is performed as a function of lateral (x, y) tip positions. In the optimal case, the collected data can be used to generate an interpretable real-time replication of sample topography and/or a genuine image of spatially resolved concentration profiles of redox active species in close vicinity to the evaluated sample and with a lateral resolution that is governed roughly by the tip dimension.

A few tens of review articles are at present available on the broad topic ‘SECM’ and they are together a good primary source of information about the theory and practice of SECM experimentation, the technical accomplishments that helped advance SECM instrumentation and, last but not least, the many special applications in the fields of materials, energy, natural and life sciences. With special focus on biological applications of SECM several reviews are recommended.

Not considering mergers with other scanning microscopy techniques such as, among others, atomic force microscopy (AFM), scanning ion conductance microscopy (SICM) and near-field optical

scanning microscopy (NSOM), the most frequently applied operation modes of SECM are the amperometric feedback and the generator/collector (G/C) modes, with the SECM tip moved at either constant z height or at constant tip-to-sample distance across the sample surface. Here, a summary of adaptations of the various technical SECM solutions for biological, single-cell and single-molecule studies is followed by the classifications of possible applications.

A careful selection of cutting-edge articles from about the last 5 years will then be summarized with the aim of highlighting the enormous level of sophistication at which SECM works on living cells and immobilized bio-macromolecules.

A discussion of the promising potentials of state-of-the-art 'biological' SECM-based detection and imaging and recommendations for near- and far-term future goals of applications of scanning miniaturized electrochemical sensors on biological cells and molecular biological entities are provided as part of the concluding section.

2. Scanning electrochemical microscopy-based live cell imaging: technical aspects, targets and potentials

Living cells are lipid double-layer membrane-confined three-dimensional small objects with heights and diameters in the low micrometre scale. They exist in primary cell cultures freshly isolated from the body tissue of interest or in secondary cell cultures as passaged constituents of cell lines. Usually, cultured living cells are used for electrophysiology experiments as seeds on thin glass coverslips or the bottom of plastic Petri dishes, with or without cell adhesion-enhancing surface layers of, for instance, poly-l-lysine. For SECM work on individual cells, careful maintenance of a

suitable density of the cell population is important just to have enough healthy but distant choices. is a graphical illustration of the principles of SECM studies on single living cells.

Selections of SECM tips for the voltammetric detection of biological cell activity include bare or chemically modified micro- or nanometre diameter disc-shaped noble metal or carbon electrodes. Independent of their size, scanning SECM tips should traverse gently over the cell to be screened and with appropriate precautions. The required contactless movement in the x/y plane is possible in computer-controlled constant-height or constant-distance modes.

A typical 'bio-SECM' is mounted on the base plate of an inverted microscope with reasonable magnification to aid the visual assessment of cell quality before approach and to facilitate coarse alignment between a healthy cell of choice and the SECM tip prior to operation.

Constant-distance mode cellular scanning electrochemical microscopy

SECM with nanometre-sized electrochemical sensors moving at constant distance over the membranes of selected cells creates images of cell topography and offers the chance for improved resolution of cell activity at neighbouring membrane locations. Moreover, it is able to explore, for instance, the spatial heterogeneity of a cell response to external stimuli. Suitable nanodisc electrodes are obviously more difficult to fabricate and handle. A collection of recent comprehensive reviews as the source of details on nanoelectrode fabrication, their electrochemical behaviour and potential applications can be found in. The operation of nanodisc electrodes on single cells requires the preservation of a

nanometre tip-to-sample working distance for the entire duration of lateral tip displacement relative to the fixed biological sample. Special feedback loop-regulated tip-to-sample distance control units were developed that use the magnitude of shear force-based dampening of intentionally induced vibrations of the nano-SECM tip as the input signal. Corresponding practical bio-SECM set-ups were realized with optical , piezoelectric or tuning fork-based readouts of tip vibration dampening. Exemplary accomplishments of shear force-supported constant-distance cellular bio-SECM prior to the actual period of this review are, for instance, the spatially resolved detection of neurotransmitter secretion from single pheochromocytoma (PC12) cells, localized measurement of stimulated NO release from adherently growing endothelial cells and simultaneous detection of the cellular expression activity of secreted alkaline phosphatase outside and green fluorescent protein inside of gene-transfected single HeLa cells . Though, currently, shear force-based feedback is the leading methodology for constant-distance SECM work on cells, the specific positioning task has also been accomplished with alternative distance-dependent signal inputs for the regulating control units.

What is Muscular and Glandular system: Types and functions Biological basis of Motivation: Hunger, Thirst, Sleep and Sex Biological basis of

emotion: The Limbic system, Hormonal regulation of behaviorGenetics and behavior: Chromosomal anomalies; Nature-Nurture controversy [Twin studies and adoption studies] ?

Muscular and Glandular system: Types and functions Biological basis of Motivation: Hunger, Thirst, Sleep and Sex Biological basis of emotion: The Limbic system, Hormonal regulation of behavior Genetics and behavior: Chromosomal anomalies; Nature-Nurture controversy [Twin studies and adoption studies]

Muscular system: Types and functions

A muscle is a group of muscle tissues which contract together to produce a force. A muscle consists of fibers of muscle cells surrounded by protective tissue, bundled together many more fibers, all surrounded in a thick protective tissue. A muscle uses ATP to contract and shorten, producing a force on the objects it is connected to. There are several types of muscle, which act on various parts of the body.

Structure of Muscle

A muscle consists of many muscle tissues bundled together and surrounded by epimysium, a tough connective tissue similar to cartilage. The epimysium surrounds bundles of nerve cells that run in long fibers, called fascicles. These fascicles are surrounded by their own protective layer, the perimysium. This layer allows

nerves and blood to flow to the individual fibers. Each fiber is then wrapped in an endomysium, another protective layer. As seen in the image below, a muscle is arranged in a basic pattern of bundled fibers separated by protective layers.

These layers and bundles allow different parts of a muscle to contract differently. The protective layer surrounding each bundle allows the different bundles to slide past one another as they contract. The epimysium connects to tendons, which attach to the periosteum connective tissue that surrounds bones. Being anchored to two bones allows movement of the skeleton when the muscle contracts. A different type of muscle surrounds many organs, and the epimysium connects to other connective tissues to produces forces on the organs, controlling everything from circulation to food processing.

Function of Muscle

Whether it is the largest muscle in your body or the tiny muscle controlling the movement of your eye, every muscle functions in a similar manner. A signal is sent from the brain along a bundle of nerves. The electronic and chemical message is passed quickly from nerve cell to nerve cell and finally arrives at the motor end plate. This interface between the muscle and nerve cells releases a chemical signal, acetylcholine, which tells the muscle fiber to contract. This message is distributed to all the cells in the fiber connected to the nerve.

This signal causes the myosin proteins to grab onto the actin filaments around them. These are the purple proteins in the image below. Myosin uses ATP as an energy source to crawl along the green filament, actin. As you can see, the many small heads of the myosin fibers crawling along the actin filaments effectively shortens

the length of each muscle cell. The cells, which are connected end-to-end in a long fibers, contract at the same time and shorten the whole fiber. When a signal is sent to an entire muscle or group of muscles, the resulting contraction results in movement or force being applied.

A muscle can be used in many different ways throughout the body. A certain muscle might contract rarely with a lot of force, whereas a different muscle will contract continually with minimal force. Animals have developed a plethora of uses for the forces a muscle can create. Muscles have evolved for flying, swimming, and running. They have also evolved to be pumps used in the circulatory and digestive systems. The heart is a specialized muscle, which is uses exclusively for pumping blood throughout the body. These different types of muscle will be discussed below.

Types of Muscle

Skeletal Muscle

When you think of a muscle, most people generally think of a skeletal muscle. The biceps, triceps, and quadriceps are all common names for muscles that body builders tend to focus on. In fact, these general muscles are often composed of many small muscles that attach to different places to give a joint its full range of motion. Skeletal muscle is a striated muscle. This means that each muscle fiber has striations, or linear marks, which can be seen when this muscle is put under a microscope. The striations correspond to the sarcomeres present in striated muscles, which are highly organized bundles of muscle cells which can contract quickly in concert.

Skeletal muscle is controlled via the somatic nervous system, also known as the voluntary nervous system. Point your finger to the

ceiling. This is your somatic nervous system in action, controlling your skeletal muscles.

Cardiac Muscle

Cardiac muscle, while similar to skeletal muscle in some ways, is connected to the autonomous nervous system. This system controls vital organs such as the heart and lungs and allows us to not have to focus on pumping our heart each time it needs to beat. While there is a certain amount of conscience control we have over the autonomous nervous system, it will always kick in when we are unconscious. For instance, you can hold your breath if you like but you do not have to remember to breathe all the time. Cardiac muscle surround the chambers of the heart and is used to pump blood through the body.

Cardiac muscle is similar to skeletal muscle in that it is striated. Unlike skeletal muscle, cardiac muscle fibers are arranged in a branching pattern instead of a linear pattern. Both skeletal muscle and cardiac muscle need to contract quickly and often, which is why the striations can be seen.

Smooth Muscle

Unlike skeletal and cardiac muscle, smooth muscle is not striated. This is because the individual muscle cells are not perfectly aligned into sarcomeres. Instead, they are displaced throughout the fibers. This gives smooth muscle the ability to contract for longer, although the contraction happens more slowly. Consider the muscle that contracts the sphincter on your bladder. This muscle may need to stay clamped shut for hours at a time and only gets a minute of relief when you go to the bathroom. Many other smooth muscles operate in the same manner.

Like cardiac muscle, smooth muscle is mostly controlled by the autonomous nervous system. The many muscles that line your digestive tract work together to move food through the digestive system Muscles attach to your hair follicles that all your hairs to stand up when it's cold. Smooth muscle is almost everywhere in your body and aids in everything from circulation to digestion.

Glandular System Types and functions

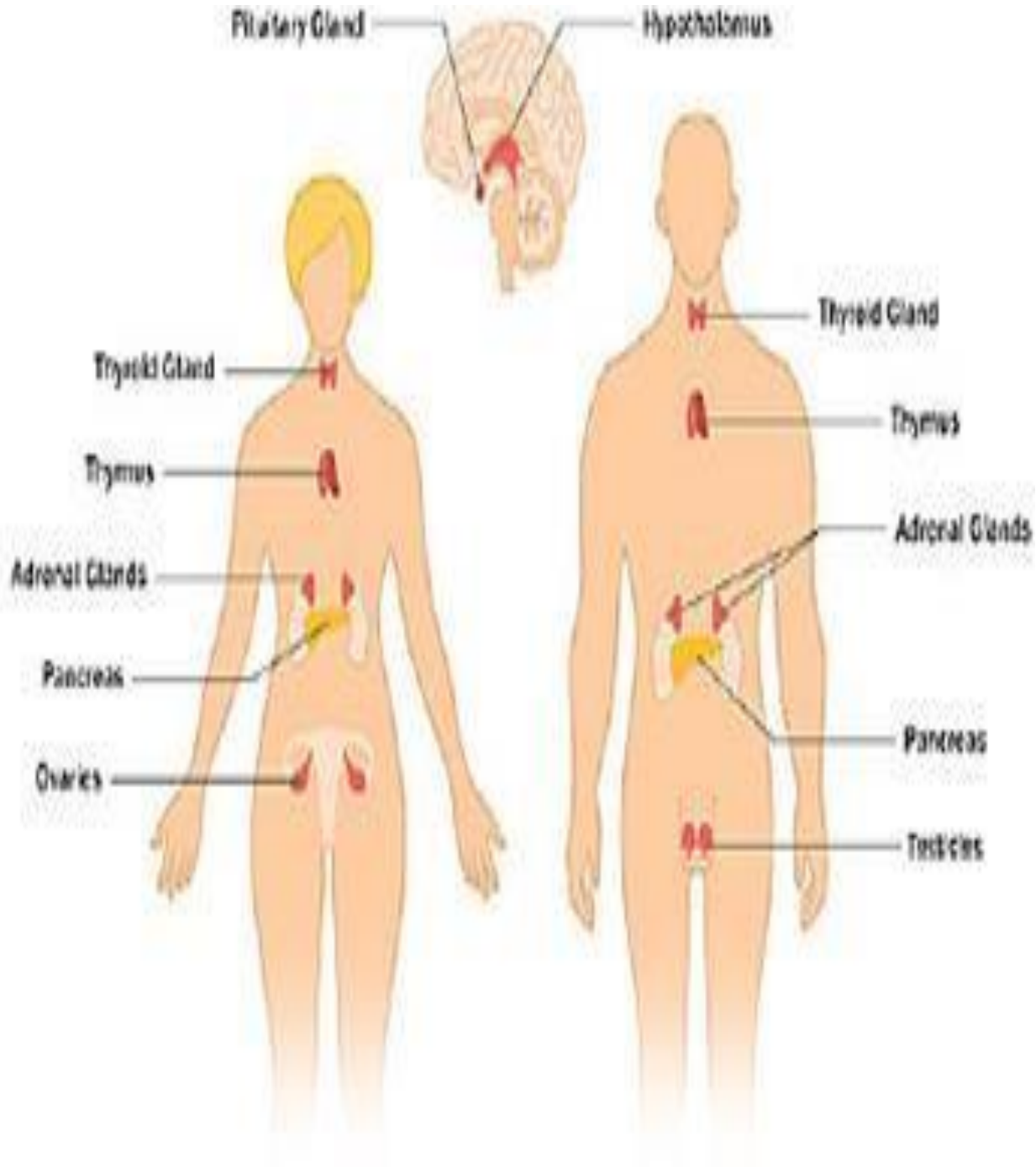
Endocrine System?

The endocrine system is a network of glands in your body that make the hormones that help cells talk to each other. They're responsible for almost every cell, organ, and function in your body.

If your endocrine system isn't healthy, you might have problems developing during puberty, getting pregnant, or managing stress. You also might gain weight easily, have weak bones, or lack energy

because too much sugar stays in your blood instead of moving into your cells where it's needed for energy.

What Is a Gland?



A gland is an organ that makes and puts out hormones that do a specific job in your body. Endocrine glands release the substances they make into your bloodstream.

Endocrine System Functions

Your endocrine system:

- Makes hormones that control your moods, growth and development, metabolism, organs, and reproduction
- Controls how your hormones are released
- Sends those hormones into your bloodstream so they can travel to other body parts

Parts of the Endocrine System

Many glands make up the endocrine system. The hypothalamus, pituitary gland, and pineal gland are in your brain. The thyroid and parathyroid glands are in your neck. The thymus is between your lungs, the adrenals are on top of your kidneys, and the pancreas is behind your stomach. Your ovaries (if you're a woman) or testes (if you're a man) are in your pelvic region.

- **Hypothalamus.** This organ connects your endocrine system with your nervous system. Its main job is to tell your pituitary gland to start or stop making hormones.
- **Pituitary gland.** This is your endocrine system's master gland. It uses information it gets from your brain to tell other glands in your body what to do. It makes many important hormones, including growth hormone; prolactin, which helps breastfeeding moms make milk; and luteinizing hormone, which manages estrogen in women and testosterone in men.
- **Pineal gland.** It makes a chemical called melatonin that helps your body get ready to go to sleep.
- **Thyroid gland.** This gland makes thyroid hormone, which controls your metabolism. If this gland doesn't make enough (a condition called hypothyroidism), everything happens more

slowly. Your heart rate might slow down. You could get constipated. And you might gain weight. If it makes too much (hyperthyroidism), everything speeds up. Your heart might race. You could have diarrhea. And you might lose weight without trying.

- **Parathyroid.** This is a set of four small glands behind your thyroid. They play a role in bone health. The glands control your levels of calcium and phosphorus.
- **Thymus.** This gland makes white blood cells called T-lymphocytes that fight infection and are crucial as a child's immune system develops. The thymus starts to shrink after puberty.
- **Adrenals.** Best known for making the "fight or flight" hormone adrenaline (also called epinephrine), these two glands also make hormones called corticosteroids. They affect your metabolism and sexual function, among other things.
- **Pancreas.** This organ is part of both your digestive and endocrine systems. It makes digestive enzymes that break down food. It also makes the hormones insulin and glucagon. These ensure you have the right amount of sugar in your bloodstream and your cells.
- If you don't make insulin, which is the case for people with type 1 diabetes, your blood sugar levels can get dangerously high. In type 2 diabetes, the pancreas usually makes some insulin but not enough.
- **Ovaries.** In women, these organs make estrogen and progesterone. These hormones help develop breasts at

puberty, regulate the menstrual cycle, and support a pregnancy.

- **Testes.** In men, the testes make testosterone. It helps them grow facial and body hair at puberty. It also tells the penis to grow larger and plays a role in making sperm.

Biological basis of Motivation

Psychologists have to gather specialized knowledge in considering the ways in which the biological structure and functions of the body affect behaviour. The biological processes are the essential part of human psychology. Our understanding of human behaviour cannot be complete without knowledge of the brain and others part of the nervous system. Biological factors are centrals to every sensory experience, states of consciousness, motivation and emotion, development through out the life span and physical and psychological health and wellbeing.

Executive summary

Biological bases influence the learning, memory, and motivation. The biological factors is very important because it is controlling our behaviour .We might not be able to understand behaviour without an understanding of our biological makeup.

Objectives of the study:

Basically this study aims to

1. Collect information on the situation of biological factors of our behaviour. 2. Explore ways how to improve the behavior.

3. The function of the neuron is fundamental biological aspects of the body.

Findings

Biological basis of learning

Learning can be defined as a relatively permanent change in behaviour based on experience. Learning is the aspect of new things by using past experience.

Many psychologists believe learning is based on the strengthening of the neural connections between stimuli and specific patterns of muscle movements, while others said that learning involvoves changes in cognition.

The existence of biological constraints is consistent with assess mental discussion of behavior. Freshly there are making suitable by alternative benefits that promote survival for organism that rapidly learn or neglecte that certain behaviors. Such as, our ability to learning avoid touching hot surfaces increase our change in survival (barkow, and tooby 1992; terry, 2003).

Neuclei areas are group of neurons forming structures with specific function. For example each of the different colour on our brain model represent and individual areas each with it own internal structure and function (Jeanette, J Norden Venderbilt university school and medicine).

Telencephalon; – consists of two cerebral hemispheres the outer covering of the hemespheres is called the cortex. The cortex is responsible for voluntary action or thought and for subjective experience.

Mesencephalon; – contain many small nuclei that are important to relexs, such as reflexs turning of the eyes toward the source of an objects or sound.

Metencephalon: – A structure that connect the cerebellum with the rest of the body and cerebellum that involved in learned skilled motor movement.

The role of biological factors of learning has an example that discussed john and his associates. On one fateful evening, they ate eight hot dog. Two hour leter, they become more than just a little nauseated. As a result, it was many year until they ate another hot dog. This experience of learning to dislike hot dogs is an example of a learned taste aversion. (Garcia, Hankins and Rusiniak, 1974)

Biological basis of memory

Memory consists in remembering what has previously been learned .It would be better, however, to say that memory consists in learning, retaining and remembering what has previously been learned (psychology; Methuen and co. Ltd; London; 1964.

Memory processes are distributed across the brain, relating to different information processing systems involve during the intitle exprosure to a stimulus. (Friedman and Donoghue 2000).

A theory stated by Canadian researchar Donald Hebb (1949) is still considerd to provide a general model of the biological process responsible for memory (Jeffrey and Reid, 1997; Tsien, 2007). According to Hebb, each experience activates a unique pattern of neurons in the brain. This activities cause structural changes to occur in those neurons near the synaptic gaps that link them. To Hebb, these changes in the functioning of synapses in the brain, which he termed ”synaptic facilition”, is the biological basis of memory.

Many different brain areas play a role in memory. The cerebellum plays critical role in the timing execution of learned, skilled motor

movement. Nuclei deep in the hemisphere called the basal ganglia are involves in motor programs. Many different areas of the brain contributes to attention, these include cortical areas of the reticular formation, all areas which contributes to alertness attention awareness.

The hippocampus is a part of the brain limbic systems that plays a centrals role in the consolidation of memories.The hippocampus is an older cortical areas involve in multiple aspects of memory. The left hippocampus is more involve in the memory facts, epesodes and words. It is also responsibility for constructing. The right hippocampus is more involve in spatial memory.The hippocampus aims in the initial encoding of information that like akind of neurological e- mail system.(smith, 2000, wheeler, Petersen, and buckner 2000, Wilson; 2000).

The results of research on the brains role in memory reveal two ways in which STM (short term memory) and LTM (long term memory). Firstly there is extensive evidence that physical changes in neural synapses are involved in LTM and but not in STM. And secondly there is evidence that different brain structures are involves in different ways in the three stage of memory.

Biological basis of motivation

Motivation:-motivation refers to the reasons why any behaviour occurs or specifically, to the forces or processes that initiate the behaviour, direct it , and contribute to its strength.(psychology , wadsworth publishing company; 1984;

Eating behaviour is subject to homeostasis, as most people's weight stays within a relatively stable range. The hypothalamus in the brain is central to the regulation of food intake. Acting as a kind of internal

weight thermostat, the hypothalamus calls for either greater or less food intake (Capaldi, 1996; woods et al, 2000; Berthoud, 2000).

Thirst is the biological process as like as drinking circuits .Drinking circuits is the association of tissue, body, and neuron with in nerve and cellus.It is associate with the hypothalamus deeply as like the other drinking circuits. (Thompson et. Al; 1980).

Sex is the powerful biological motivation. The sex motivations easily understand the influence of sex hormone. It is related with the increase of age. Sex hornmone influence the body to create akind of presser for sex activies. This presser to be continued that time the sex activites is not complete. (Morgan, king. Weisz and schopler, 1993).

Most of the motivation are based on the body's need to maintain a certain level of essential elements; adequate sugar in the blood in the nourish cell , enough water in the body. This levels are regulated to homeostatic mechanism. These mechanism imbalance in the body and stimulate action that restore the proper balance.

Hunger

The biological drive of **hunger**, or desiring to eat, relates to the end of this motivated behavior once we are full, called **satiety**. Basically, we eat because there is a deprivation in the amount of glucose in our blood to sustain activity and once we have restored that glucose level to its set point, hunger ends. In other words, we have achieved homeostasis again. The feeling of hunger is not pleasant and results in feeling shaky, lethargic, and possibly being sick to our stomach. We want to do something about this. So how do we know when to eat?

Signals arise from both the stomach (surprising, right?) and the blood, but the stomach plays less of a role then we might realize. We all have experienced hunger pangs or our stomach growling, or the feeling of being full especially after one of our main food holidays (Christmas, Easter, or Thanksgiving). These stomach indicators relate to being very hungry (i.e. being famished) or very full (i.e. stuffed) but that is about it.

What about other possible signals? I mentioned the blood and the brain receives information from the blood about levels of glucose, or sugar used by body cells for energy. When our glucose levels are low we are motivated to eat and restore these levels. The brain also regulates hunger through the action of the hormone ghrelin which increases appetite and leptin which reduces appetite. Other important hormones include GLP-1 which reduces appetite and tells the pancreas to release insulin, CCK which improves digestion by reducing the rate at which food is emptied from the stomach and into the small intestine, PPY

which causes satiety by being secreted into the bloodstream by the small intestine and then binding to receptor sites in the brain, and neuropeptide Y which leads to increased consumption of carbohydrates.

Though many areas of the brain are involved in the regulation of hunger, the **hypothalamus** plays a pivotal role. In terms of knowing when to start eating, the lateral hypothalamus is involved and if stimulated with an electrode, an animal that is in a state of satiation will begin eating. In terms of satiety,

the ventromedial hypothalamus tells an animal to stop eating but if destroyed, overeating results. Finally, the paraventricular nucleus is

involved in satiety as shown by stimulating it and in overeating if destroyed or damaged. It helps to regulate blood sugar levels.

In addition to these internal signals to eat, several external cues are important too. First, we sometimes eat not because we are hungry, but because it is time to eat.

Time of day factors in such that most people eat at noon because our society has been told that we should eat then.

Or we might eat on our lunch break at work whether we are hungry or not. Second, social factors play in. We may eat because our friends are doing so and don't want to be left out. Third, the sight of food, or its smell, may motivated us to eat. Fourth, to deal with life we sometimes engage in comfort eating as a tension reduction strategy, or to deal with stress (See Module 4).

Fifth, but more so a cue as to what to eat, culture plays in. Some cultures find our eating of ground beef from cows to be appalling, as much as we find their eating of cats or dogs to be so. Sixth, and as mentioned already, we tend to overeat during certain times of the year such as holidays – Thanksgiving, Christmas, and Easter.

Going back to our discussion of behavioral change from Module 6, if we are trying to get in shape by reducing our caloric intake, we need to take into consideration temptations that could lead us to engage in undesirable or problem behavior. Social eating is one such example of eating when we are not actually hungry.

Thirst

There are two kinds of thirst that we can experience. Yes, two. If you eat a salty meal you experience the first type called **intracellular thirst**. Excessive salt, such as found in potato chips, causes fluid to be drawn out of our cells and as they "shrink"

we become thirsty. No worries. If we drink water (nothing added to it such as the flavor aides) we can restore this deficiency. The second type of thirst occurs when we are sweating, have diarrhea, vomit, or are bleeding, and is called **extracellular thirst**. Essentially, water is lost from the fluid surrounding our cells and drinking a saline solution helps such as Gatorade or Powerade.

Sleep

Though we know that sleep is a necessary requirement for all human beings, and is essential for survival, the exact reason(s) is/are not as clear. We spend about one-third of our time sleeping. Several brain structures are involved in the regulation of sleep. First, the hypothalamus contains the **suprachiasmatic nucleus** (SCN) which is a cluster of cells that receives information about light exposure from the eyes and controls our behavioral rhythms. People with damage to this area sleep erratically during the day because their light-dark cycle and circadian rhythms are not in synch. During all stages of sleep but REM sleep, the **thalamus**, or sensory relay station, becomes quiet and allows you to tune out the external world. The **pineal gland** receives signals from the SCN and increases production of the hormone melatonin, which aids in sleeping once the lights are off.

Sleep is regulated by two internal biological mechanisms. First, **circadian rhythms** affect fluctuations in wakefulness, metabolism, body temperature, and the release of hormones. Specifically, they control the timing of sleep and lead you to feel sleepy at night. Second, sleep-wake homeostasis tracks how much sleep you need and gives the body a reminder to sleep after a certain amount of time. It also regulates sleep intensity.

How much sleep do you need? There is no magic number and in general, it is recommended that adults sleep 7-9 hours a night while babies sleep 16-18 hours a day and school-aged children and teens sleep about 9.5 hours.

Sex

Sexual behavior is an interesting type of motivated behavior as it is not needed for survival in the same sense as hunger or thirst, but is needed for reproduction and continuation of the species. Understanding sexual behavior is important, as a 2017 survey conducted by the Centers for Disease Control and Prevention (CDC) of high school students shows:

- 40% of students said they had sexual intercourse
- 10% have had more than one sexual partner
- 30% had sexual intercourse during the previous 3 months and of this, 46% did not use a condom the last time they had sex and 14% did not use any method to prevent pregnancy.
- In terms of health outcomes, 21% of all new HIV diagnoses in the US in 2016 were people aged 13-24, half of the 20 million new STD cases in the US were people aged 15-24, and about 210,000 babies were born to girls aged 15-19 in 2016

Human sexual behavior is activated by the sex hormones estrogens, progestins, and androgens. All three circulate in the blood of males and females but females have greater levels of the first two and males have higher levels of the last. Recall from Module 10 that during adolescence hormone levels rise and lead to increases in sexual desire and behavior.

According to Masters and Johnson (1966) there is a distinct pattern of physiological arousal for men and women, before, during, and after sexual activity, and called the **sexual response pattern**.

How so? Phase 1 is excitement and is characterized by increased muscle tension, faster heart rate, the breasts becoming fuller and the nipples hardening, vaginal lubrication beginning, and the man secreting a lubricating liquid. Phase 2 is plateau and extends to the brink of orgasm and is an intensification of the changes began in phase 1.

Phase 3 is orgasm and is the climax of the cycle but lasts only a few seconds. The uterus in women and the penis in men undergo rhythmic contractions, and in men results in the ejaculation of semen.

For men and women, the phase is intensely pleasurable and leads to a release of both physical and psychological tension. Phase 4 is resolution and now the body returns to its normal level of functioning. Swelled or erect body parts return to normal and sexual partners experience intimacy, fatigue, and a general sense of well-being.

Men enter a refractory period during which they cannot achieve an orgasm again. How long this last depends on the man and the time lengthens with age.

Biological basis of emotion: The Limbic system, Hormonal regulation of behavior

The experience of emotion is accompanied by activation of two major areas of the nervous system: the brain and the autonomic nervous system.

Activation of Brain Regions

The area of the brain known as the **Limbic System** is highly involved in emotion. One structure in the limbic system, called the **Amygdala**, plays a particularly important role in regulating emotion.

Researchers believe that sensory information about emotion-evoking events moves along two pathways in the brain. The information goes first to the thalamus and from there moves simultaneously to the amygdala and the cortex of the brain. The amygdala processes the information quickly and sends signals to the hypothalamus, which in turn activates the autonomic nervous system. The cortex, on the other hand, processes the information more slowly, allowing people to appraise or evaluate the event.

Example: When information travels from the sense organs to the thalamus to the amygdala, people respond instantaneously, without thinking, to events in their environment. A parent may snatch her child away from a curb without thinking if she hears the sound of squealing tires coming toward them.

KEY TAKEAWAYS

Key Points

- The limbic system, autonomic nervous system, and reticular activating system all interact in the physiological processing of emotion.
- The limbic system categorizes human emotional experiences as either pleasant or unpleasant mental states. Neurochemicals such as dopamine, noradrenaline, and serotonin are important components of the limbic system.

- The autonomic nervous system, together with the hypothalamus, regulates pulse, blood pressure, breathing, and arousal in response to emotional cues.
- When activated, the sympathetic nervous system prepares the body for emergency actions by controlling the glands of the endocrine system. Conversely, the parasympathetic nervous system functions when the body is relaxed or at rest and helps the body store energy for future use.
- The reticular activating system is believed to first arouse the cortex and then maintain its wakefulness so that sensory information and emotion can be interpreted more effectively.

Key Terms

- **homeostasis**: Equilibrium of the body, in which biological conditions (such as body temperature) are maintained at optimal levels.
- **cerebral cortex**: The grey, folded, outermost layer of the cerebrum that is responsible for higher brain processes such as sensation, voluntary muscle movement, thought, reasoning, and memory.
- **amygdala**: A part of the brain located in the medial temporal lobe. It is believed to play a key role in emotion in both animals and humans, particularly in the formation of fear-based memories.
- **hippocampus**: A part of the limbic system, located in the temporal lobe of the brain and consisting mainly of grey matter. It plays a role in memory and emotion.

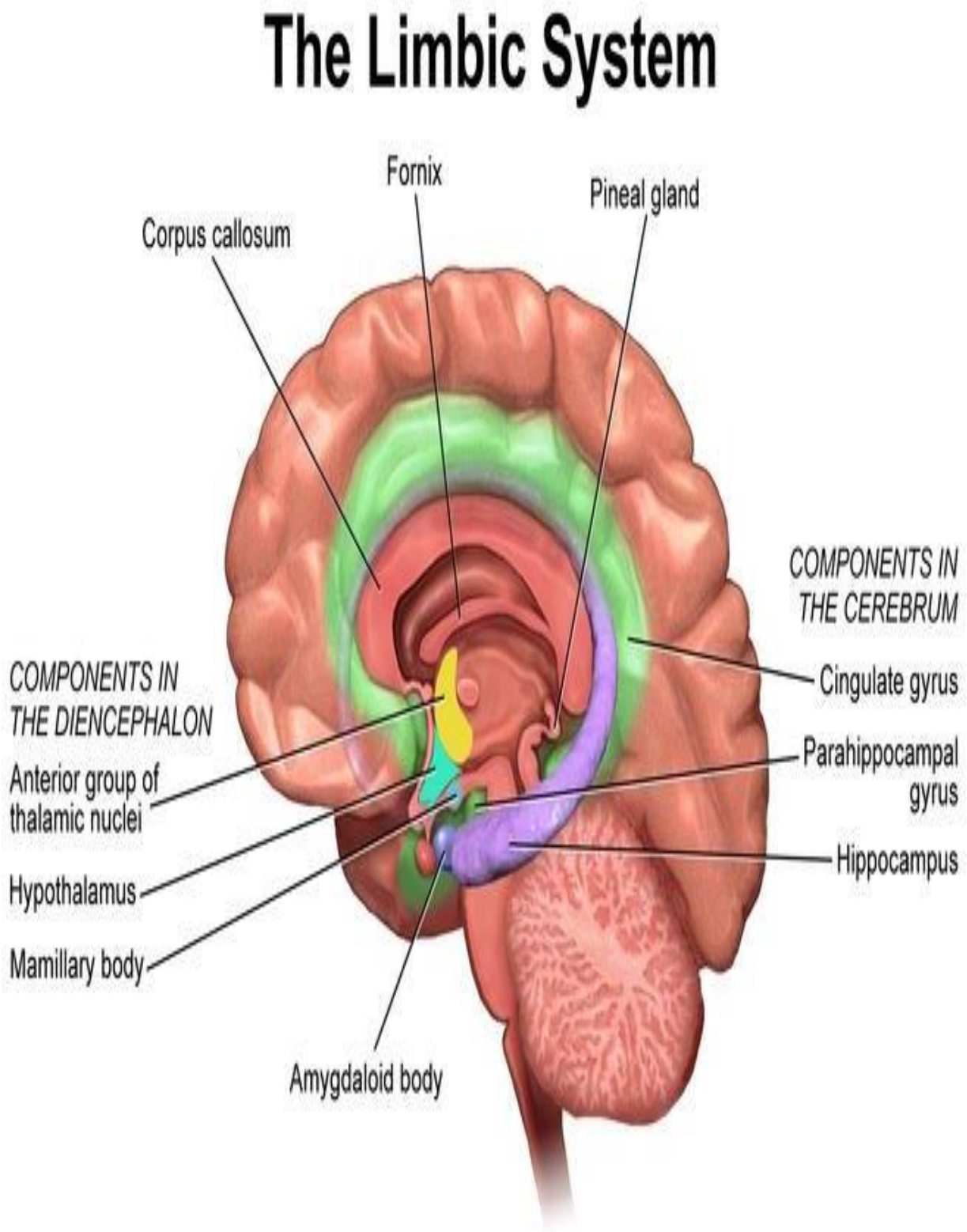
- **emotion**: The complex psychophysiological experience of an individual's state of mind as it is interacting with biochemical (internal) and environmental (external) influences.

Emotions can be explained in biological and neurological terms. The limbic system, autonomic nervous system, and reticular activating system all interact to assist the body in experiencing and processing emotions.

The Limbic System

The limbic system is the area of the brain most heavily implicated in emotion and memory. Its structures include the hypothalamus, thalamus, amygdala, and hippocampus. The hypothalamus plays a role in the activation of the sympathetic nervous system, which is a part of any emotional reaction. The thalamus serves as a sensory relay center; its neurons project signals to both the amygdala and the higher cortical regions for further processing. The amygdala plays a role in processing emotional information and sending that information on to cortical structures. The hippocampus integrates emotional experience with cognition.

Other parts of the limbic system include the olfactory bulbs, anterior nuclei, fornix, column of fornix, mammillary body, septum pellucidum, habenular commissure, cingulate gyrus, parahippocampal gyrus, limbic cortex, and limbic midbrain areas.


The Limbic System
Fornix
Pineal gland
Corpus callosum
COMPONENTS IN THE CEREBRUM
Cingulate gyrus
Parahippocampal gyrus
Hippocampus
COMPONENTS IN THE DIENCEPHALON
Anterior group of thalamic nuclei
Hypothalamus
Mamillary body
Amygdaloid body

The limbic system: The limbic system is the area of the brain involved with emotion and memory. Its structures include the hypothalamus, thalamus, amygdala, and hippocampus

The processes of the limbic system control our physical and emotional responses to environmental stimuli. This system categorizes the experience of an emotion as a pleasant or unpleasant mental state. Based on this

categorization, neurochemicals such as dopamine, noradrenaline, and serotonin increase or decrease, causing the brain's activity level to fluctuate and resulting in changes in body movement, gestures, and poses.

Hormones and Behavior: Basic Concepts

Behavioral endocrinology is the scientific study of the interaction between hormones and behavior. This interaction is bidirectional: hormones can affect behavior, and behavior can feedback to influence hormone concentrations. Hormones are chemical messengers released from endocrine glands that influence the nervous system to regulate the physiology and behavior of individuals.

Over evolutionary time, hormones regulating physiological processes have been co-opted to influence behaviors linked to these processes. For example, hormones associated with gamete maturation such as estrogens are now broadly associated with the regulation of female sexual behaviors.

Such dual hormonal actions ensure that mating behavior occurs when animals have mature gametes available for fertilization. Generally speaking, hormones change gene expression or cellular

function, and affect behavior by increasing the likelihood that specific behaviors occur in the presence of precise stimuli.

Hormones achieve this by affecting individuals' sensory systems, central integrators, and/or peripherial effectors. To gain a full understanding of hormone–behavior interactions, it is important to monitor hormone values, as well as receptor interactions in the brain. Because certain chemicals in the environment can mimic natural hormones, these chemicals can have profound effects on the behavior of humans and other animals.

Behavioral Endocrinology Techniques A number of methods are used to gather the evidence needed to establish hormone–behavior relationships. Much of the recent progress in behavioral endocrinology has resulted from technical advances in the tools that allow us to detect, measure, and probe the functions of hormones and their receptors. These techniques, with a brief description, are listed in Table

1. Several of these techniques are the result of advanced research in behavioral endocrinology, including the time-honored ablation-replacement techniques, bioassays, as well as modern assays that utilize the concept of competitive binding of antibodies that include radioimmunoassay (RIA),

enzyme-linked immunosorbent assay (ELISA; enzyme-linked immunoassay (EIA)), autoradiography, and immunocytochemistry. Other techniques commonly used in behavioral endocrinology include neural stimulation and single-unit recording, techniques that activate or block hormone receptors with drugs, and gene arrays and genetic manipulations including interfering with RNA and use of viral gene vectors to deliver novel genes directly into the brain. Because hormones must interact with specific receptors to evoke a

response, many of these techniques are used to influence or measure hormone secretion, hormone binding, or the physiological and behavioral effects that ensue after hormones bind to their respective receptors.

Hormones

Hormones are organic chemical messengers produced and released by specialized glands called ‘endocrine glands.’ Endocrine is derived from the Greek root words endon, meaning ‘within,’ and krinein, meaning ‘to release,’ whereas the term hormone is based on the Greek word hormon, meaning ‘to excite.’ Hormones are released from these glands into the bloodstream (or the tissue fluid system in invertebrates), where they act on target organs (or tissues) generally at some distance from their origin. Hormones coordinate the physiology and behavior of an animal by regulating, integrating, and controlling its bodily function. Hormones are similar in function to other chemical mediators including neurotransmitters and cytokines. Indeed, the division of chemical mediators into categories mainly reflects the need by researchers to organize biological systems into endocrine, nervous, and immune systems, rather than real functional differences among these chemical signals. Hormones often function locally as neurotransmitters and also interact with neurotransmitters and cytokines to influence behavior.

Hormones can be grouped into four classes:

(1) peptides or proteins,

(2) steroids,

(3) monoamines, and

(4) lipidbased hormones. Generally,

only one class of hormone is produced by a single endocrine gland, but there are some notable exceptions.

It is important and useful to discriminate among the four types of hormones because they differ in several important characteristics, including their mode of release, how they move through the blood, the location of their target tissue receptors, and the manner by which the interaction of the hormone with its receptor results in a biological response.

Protein Hormones

Most vertebrate hormones are proteins. Protein hormones that comprise only a few amino acids in length are called ‘peptide hormones,’ whereas larger ones are called ‘protein’ or ‘polypeptide hormones.’ Protein and peptide hormones include insulin, the glucagons, the neurohormones of the hypothalamus, the tropic hormones of the anterior pituitary, inhibin, calcitonin, parathyroid hormone, the gastrointestinal (gut) hormones, ghrelin, leptin, adiponectin, and the posterior pituitary hormones. Protein and peptide hormones can be stored in endocrine cells and are released into the circulatory system by means of exocytosis. Protein and peptide hormones are soluble in blood, and therefore, do not require a carrier protein to travel to their target cells, as do steroid hormones.

Steroid Hormones

The adrenal glands, the gonads, and the brain are the most common sources of steroid hormones in vertebrates. Vertebrate steroid hormones have a characteristic chemical structure that includes three six-carbon rings plus one conjugated five-carbon ring. In the nomenclature of steroid biochemistry, substances are

identified by the number of carbon atoms in their chemical structure. The precursor to all vertebrate steroid hormones is cholesterol.

The cholesterol molecule contains 27 carbon atoms (a C27 substance), although cholesterol itself is not a true steroid and can be stored within lipid droplets inside cells. Because steroid hormones are fat soluble and move easily through cell membranes, they are never stored, but leave the cells in which they were produced almost immediately. A signal to produce steroid hormones is also a signal to release them.

How Might Hormones Affect Behavior?

All behavioral systems, including animals, comprise three interacting components:

(1) input systems (sensory systems),

(2) integrators (the central nervous system), and

(3) output systems, or effectors (e.g., muscles).

Again, hormones do not cause behavioral changes. Rather, hormones influence these three systems so that specific stimuli are more likely to elicit certain responses in the appropriate behavioral or social context. In other words, hormones change the probability that a particular behavior will be emitted in the appropriate situation. This is a critical distinction that affects conceptualization of hormone–behavior relationships. For example, female rodents must adopt a rigid mating posture (called ‘lordosis’) for successful copulation to occur.

Females only show this posture when blood estrogen concentrations are high coincident with the maturing ova. Females adopt the lordosis posture in repsonse to tactile stimuli provided by

a mounting male. Estrogens affect sensory input by increasing the receptive field size in sensory cells in the flanks.

Estrogen affects protein synthesis, the electrophysiological responses of neurons, and the appearance of growth-like processes on neurons in the central nervous system, thus altering the speed of processing and connectivity of neurons. Finally, estrogen affects the muscular output that results in lordosis, as well as chemosensory stimuli important in attracting a mating partner.

How Might Behavior Affect Hormones?

The female rodent mating posture example demonstrates how hormones can affect behavior, but, as noted previously, the reciprocal relation also occurs, that is, behavior can affect hormone concentrations.

For example, chemosensory cues from males may elevate blood estradiol concentrations in females, and thereby stimulate proceptive or male-seeking behaviors. Similarly, male mammals that lose an aggressive encounter decrease circulating testosterone concentrations for several days or even weeks afterward. Similar results have also been reported in humans.

Human testosterone concentrations are affected not only in those involved in physical combat, but also in those involved in simulated battles. For example, testosterone concentrations are elevated in winners and reduced in losers of regional chess tournaments.

Types of Evidence for Establishing Hormone–Behavior Interactions

What sort of evidence would be sufficient to establish that a particular hormone affected a specific behavior or that a specific behavior changed hormone concentrations? Experiments to test

hypotheses about the effects of hormones on behavior must be carefully designed, and, generally, three conditions must be satisfied by the experimental results to establish a causal link between hormones and behavior:

(1) a hormonally dependent behavior should disappear when the source of the hormone is removed or the actions of the hormone are blocked,

(2) after the behavior stops, restoration of the missing hormonal source or its hormone should reinstate the absent behavior, and

(3) finally, hormone concentrations and the behavior in question should be covariant, that is, the behavior should be observed only when hormone concentrations are relatively high and never or rarely observed when hormone concentrations are low.

Genetics and behavior: Chromosomal anomalies; Nature-Nurture controversy [Twin studies and adoption studies]

Behaviour genetics, also called psychogenetics, the study of the influence of an organism's genetic composition on its behaviour and the interaction of heredity and environment insofar as they affect behaviour.

The question of the determinants of behavioral abilities and disabilities has commonly been referred to as the "nature-nurture" controversy.

Early History

The relationship between behaviour and genetics, or heredity, dates to the work of English scientist Sir Francis Galton (1822–1911), who coined the phrase “nature and nurture.” Galton studied the families of outstanding men of his day and concluded, like his cousin Charles Darwin, that mental powers run in families.

Galton became the first to use twins in genetic research and pioneered many of the statistical methods of analysis that are in use today. In 1918 British statistician and geneticist Ronald Aylmer Fisher published a paper that showed how Gregor Mendel’s laws of inheritance applied to complex traits influenced by multiple genes and environmental factors.

The first human behavioral genetic research on intelligence and mental illness began in the 1920s, when environmentalism (the theory that behaviour is a result of nongenetic factors such as various childhood experiences) became popular and before Nazi Germany’s abuse of genetics made the notion of hereditary influence abhorrent. Although genetic research on human behaviour continued throughout the following decades, it was not until the 1970s that a balanced view came to prevail in psychiatry that recognized the importance of nature as well as nurture. In psychology, this reconciliation did not take hold until the 1980s. Much behavioral genetic research today focuses on identifying specific genes that affect behavioral dimensions, such as personality and intelligence, and disorders, such as autism, hyperactivity, depression, and schizophrenia.

Methods Of Study

Quantitative genetic methods are used to estimate the net effect of genetic and environmental factors on individual differences in any complex trait, including behavioral traits. In addition, molecular

genetic methods are used to identify specific genes responsible for genetic influence. Research is carried out in both animals and humans; however, studies using animal models tend to provide more-accurate data than studies in humans because both genes and environment can be manipulated and controlled in the laboratory.

By mating related animals such as siblings for many generations, nearly pure strains are obtained in which all offspring are genetically highly similar. It is possible to screen for genetic influence on behaviour by comparing the behaviour of different inbred strains raised in the same laboratory environment. Another method, known as selective breeding, evaluates genetic involvement by attempting to breed for high and low extremes of a trait for several generations. Both methods have been applied to a wide variety of animal behaviours, especially learning and behavioral responses to drugs, and this research provides evidence for widespread influence of genes on behaviour.

Because genes and environments cannot be manipulated in the human species, two quasi-experimental methods are used to screen for genetic influence on individual differences in complex traits such as behaviour.

The twin method relies on the accident of nature that results in identical (monozygotic, MZ) twins or fraternal (dizygotic, DZ) twins. MZ twins are like clones, genetically identical to each other because they came from the same fertilized egg. DZ twins, on the other hand, developed from two eggs that happened to be fertilized at the same time. Like other siblings, DZ twins are only half as similar genetically as MZ twins.

To the extent that behavioral variability is caused by environmental factors, DZ twins should be as similar for the behavioral trait as are MZ twins because both types of twins are reared by the same parents in the same place at the same time. If the trait is influenced by genes, then DZ twins ought to be less similar than MZ twins.

For schizophrenia, for example, the concordance (risk of one twin's being schizophrenic if the other is) is about 45 percent for MZ twins and about 15 percent for DZ twins.

For intelligence as assessed by IQ tests, the correlation, an index of resemblance (0.00 indicates no resemblance and 1.00 indicates perfect resemblance), is 0.85 for MZ twins and 0.60 for DZ twins for studies throughout the world of more than 10,000 pairs of twins.

The twin method has been robustly defended as a rough screen for genetic influence on behaviour.

Chromosomal Abnormalities

Almost every cell in our body contains 23 pairs of chromosomes, for a total of 46 chromosomes. Half of the chromosomes come from our mother, and the other half come from our father. The first 22 pairs are called autosomes. The 23rd pair consists of the sex chromosomes, X and Y. Females usually have two X chromosomes, and males usually have one X and one Y chromosome in each cell. All of the information that the body needs to grow and develop comes from the chromosomes. Each chromosome contains thousands of genes, which make proteins that direct the body's development, growth, and chemical reactions.

Many types of chromosomal abnormalities exist, but they can be categorized as either numerical or structural. Numerical abnormalities are whole chromosomes either missing from or extra

to the normal pair. Structural abnormalities are when part of an individual chromosome is missing, extra, switched to another chromosome, or turned upside down.

Chromosomal abnormalities can occur as an accident when the egg or the sperm is formed or during the early developmental stages of the fetus. The age of the mother and certain environmental factors may play a role in the occurrence of genetic errors. Prenatal screening and testing can be performed to examine the chromosomes of the fetus and detect some, but not all, types of chromosomal abnormalities.

Chromosomal abnormalities can have many different effects, depending on the specific abnormality. For example, an extra copy of chromosome 21 causes Down syndrome (trisomy 21). Chromosomal abnormalities can also cause miscarriage, disease, or problems in growth or development.

The most common type of chromosomal abnormality is known as aneuploidy, an abnormal chromosome number due to an extra or missing chromosome.Most people with aneuploidy have trisomy (three copies of a chromosome) instead of monosomy (single copy of a chromosome). Down syndrome is probably the most well-known example of a chromosomal aneuploidy. Besides trisomy 21, the major chromosomal aneuploidies seen in live-born babies are: trisomy 18; trisomy 13; 45, X (Turner syndrome); 47, XXY (Klinefelter syndrome); 47, XYY; and 47, XXX.

Structural chromosomal abnormalities result from breakage and incorrect rejoining of chromosomal segments. A range of structural chromosomal abnormalities result in disease. Structural rearrangements are defined as balanced if the complete chromosomal set is still present, though rearranged, and

unbalanced if information is additional or missing. Unbalanced rearrangements include deletions, duplications, or insertions of a chromosomal segment. Ring chromosomes can result when a chromosome undergoes two breaks and the broken ends fuse into a circular chromosome. An isochromosome can form when an arm of the chromosome is missing and the remaining arm duplicates.

Balanced rearrangements include inverted or translocated chromosomal regions. Since the full complement of DNA material is still present, balanced chromosomal rearrangements may go undetected because they may not result in disease. A disease can arise as a result of a balanced rearrangement if the breaks in the chromosomes occur in a gene, resulting in an absent or nonfunctional protein, or if the fusion of chromosomal segments results in a hybrid of two genes, producing a new protein product whose function is damaging to the cell.

Nature-Nurture controversy [Twin studies and adoption studies]

Genetics researchers now know that while an individual's DNA is essentially immutable, a wide range of environmental factors can confer what are called epigenetic differences. Epigenetics influences which genes in an individual's genome may be turned on or turned off. Such factors as exercise, sleep, trauma, aging, stress, illness and diet have been shown to have epigenetic effects, some of which can be passed on to future generations.

Researchers are seeking ways to deliberately alter gene expression in hopes of finding preventives or treatments for diseases like diabetes with a strong genetic component.

There can also be changes in the genome of an identical twin when the egg divides, resulting in a defect in a particular gene, Dr. Segal said. In a pair of identical twin girls, one can experience a phenomenon called X-linked inactivation. Two of the identical Dionne quintuplets were colorblind as a result of such a genetic effect.

Dr. Segal, who has also written "Twin Misconceptions: False Beliefs, Fables, and Facts About Twins," said the studies highlight the importance of keeping twins, especially identical twins, together when they are adopted. As was depicted in the documentary, Dr. Segal said, "The triplets deeply resented having been separated. They lost out on wonderful years they could have had together. There was an immediate bond, an understanding of one another, that was obvious as soon as they found each other."

New research into epigenetics—the science of how the environment influences genetic expression—is changing the conversation. As psychologist David S. Moore explains in his newest book, The Developing Genome, this burgeoning field reveals that what counts is not what genes you have so much as what your genes are doing. And what your genes are doing is influenced by the ever-changing environment they're in. Factors like stress, nutrition, and exposure to toxins all play a role in how genes are expressed—essentially which genes are turned on or off. Unlike the static conception of nature or nurture, epigenetic research demonstrates how genes and environments continuously interact to produce characteristics throughout a lifetime.

The Nature vs. Nurture Debate

Are you the way you are because you were born that way, or because of the way you were raised? Do your genetics and biology

dictate your personality and behavior, or is it your environment and how you were raised? These questions are central to the age-old **nature-nurture** debate.

In the history of psychology, no other question has caused so much controversy and offense: We are so concerned with nature–nurture because our very sense of moral character seems to depend on it. While we may admire the athletic skills of a great basketball player, we think of his height as simply a gift, a payoff in the "genetic lottery." For the same reason, no one blames a short person for his height or someone's congenital disability on poor decisions: To state the obvious, it's "not their fault." But we do praise the concert violinist (and perhaps her parents and teachers as well) for her dedication, just as we condemn cheaters, slackers, and bullies for their bad behavior.The problem is,

most human characteristics aren't usually as clear-cut as height or instrument-mastery, affirming our nature–nurture expectations strongly one way or the other. In fact, even the great violinist might have some inborn qualities—perfect pitch, or long, nimble fingers—that support and reward her hard work. And the basketball player might have eaten a diet while growing up that promoted his genetic tendency for being tall. When we think about our own qualities, they seem under our control in some respects, yet beyond our control in others. And often the traits that don't seem to have an obvious cause are the ones that concern us the most and are far more personally significant. What about how much we drink or worry? What about our honesty, or religiosity, or sexual orientation? They all come from that uncertain zone, neither fixed by nature nor totally under our own control.

Figure 1. Researchers have learned a great deal about the nature-nurture dynamic by working with animals. But of course many of the techniques used to study animals cannot be applied to people.

Separating these two influences in human subjects is a greater research challenge. [Photo: mharrsch]

With people, however, we can't assign babies to parents at random, or select parents with certain behavioral characteristics to mate, merely in the interest of science (though history does include horrific examples of such practices, in misguided attempts at "eugenics," the shaping of human characteristics through intentional breeding). In typical human families, children's biological parents raise them, so it is very difficult to know whether children act like their parents due to genetic (nature) or environmental (nurture) reasons. Nevertheless, despite our restrictions on setting up human-based experiments, we do see real-world examples of nature-nurture at work in the human sphere—though they only provide partial answers to our many questions. The science of how genes and environments work together to influence behavior is called **behavioral genetics**. The easiest opportunity we have to observe this is the **adoption study**. When children are put up for adoption, the parents who give birth to them are no longer the parents who raise them. This setup isn't quite the same as the experiments with dogs (children aren't assigned to random adoptive parents in order to suit the particular interests of a scientist) but adoption still tells us some interesting things, or at least confirms some basic expectations. For instance, if the biological child of tall parents were adopted into a family of short people, do you suppose the child's growth would be affected? What about the biological child of a Spanish-speaking family adopted at birth into an English-speaking family? What language would you expect the child to speak? And what might these outcomes tell you about the difference between height and language in terms of nature-nurture?

Figure 2. Studies focused on twins have lead to important insights about the biological origins of many personality characteristics.

Another option for observing nature-nurture in humans involves **twin studies**. There are two types of twins: monozygotic (MZ) and dizygotic (DZ). Monozygotic twins, also called "identical" twins, result from a single zygote (fertilized egg) and have the same DNA. They are essentially clones. Dizygotic twins, also known as "fraternal" twins, develop from two zygotes and share 50% of their DNA. Fraternal twins are ordinary siblings who happen to have been born at the same time. To analyze nature–nurture using twins, we compare the similarity of MZ and DZ pairs. Sticking with the features of height and spoken language, let's take a look at how nature and nurture apply: Identical twins, unsurprisingly, are almost

perfectly similar for height. The heights of fraternal twins, however, are like any other sibling pairs: more similar to each other than to people from other families, but hardly identical. This contrast between twin types gives us a clue about the role genetics plays in determining height.

Now consider spoken language. If one identical twin speaks Spanish at home, the co-twin with whom she is raised almost certainly does too. But the same would be true for a pair of fraternal twins raised together. In terms of spoken language, fraternal twins are just as similar as identical twins, so it appears that the genetic match of identical twins doesn't make much difference. Twin and adoption studies are two instances of a much broader class of methods for observing nature-nurture called **quantitative genetics**, the scientific discipline in which similarities among individuals are analyzed based on how biologically related they are. We can do these studies with siblings and half-siblings, cousins, twins who have been separated at birth and raised separately (Bouchard, Lykken, McGue, & Segal, 1990; such twins are very rare and play a smaller role than is commonly believed in the science of nature–nurture), or with entire extended families (see Plomin, DeFries, Knopik, & Neiderhiser, 2012, for a complete introduction to research methods relevant to nature–nurture).

For better or for worse, contentions about nature–nurture have intensified because quantitative genetics produces a number called a **heritability coefficient**, varying from 0 to 1, that is meant to provide a single measure of genetics' influence of a trait. In a general way, a heritability coefficient measures how strongly differences among individuals are related to differences among their genes. But beware: Heritability coefficients, although simple to compute, are deceptively difficult to interpret. Nevertheless,

numbers that provide simple answers to complicated questions tend to have a strong influence on the human imagination, and a great deal of time has been spent discussing whether the heritability of intelligence or personality or depression is equal to one number or another.

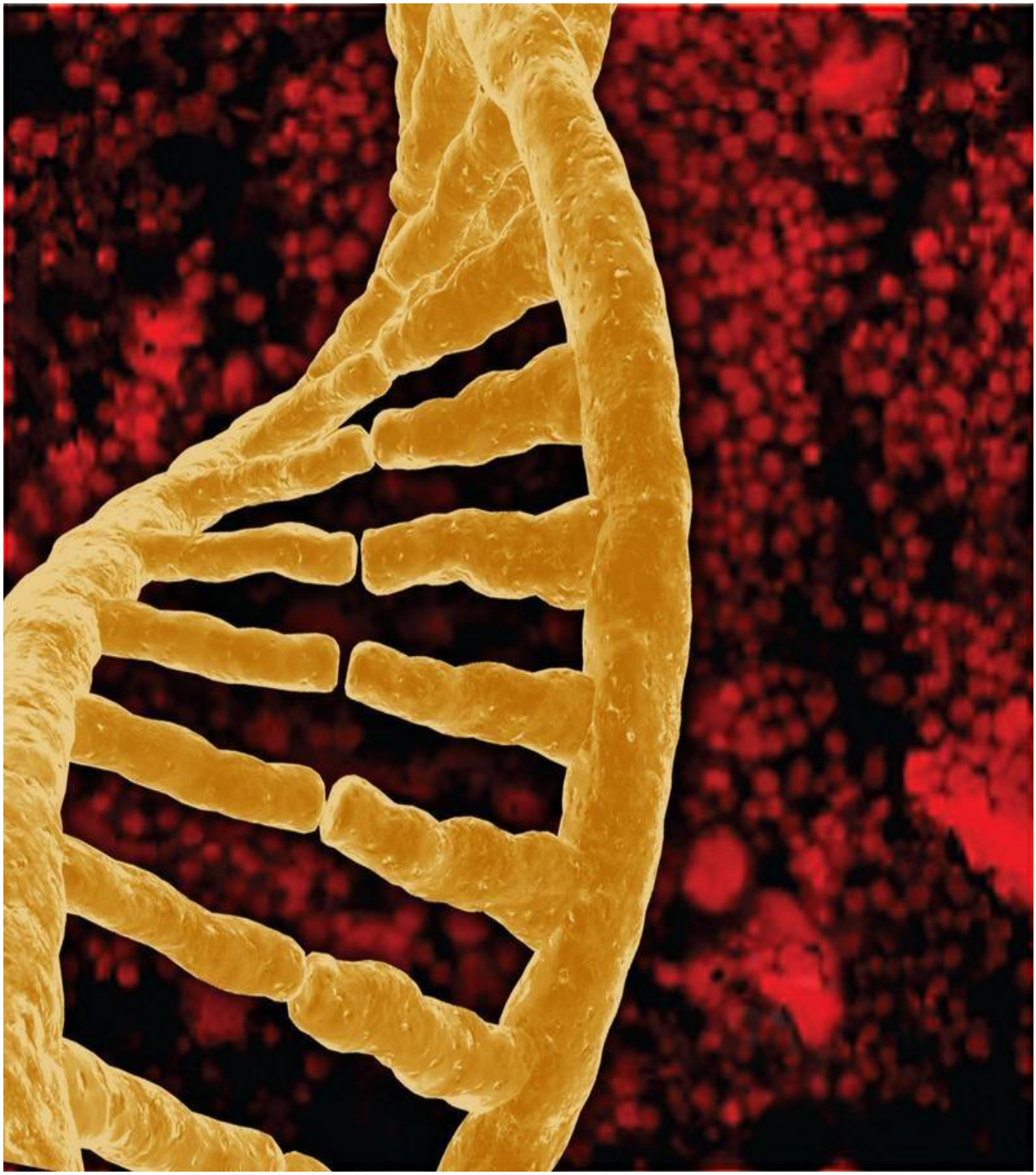


Figure 3. Quantitative genetics uses statistical methods to study the effects that both heredity and environment have on test subjects. These methods have provided us with the heritability coefficient which measures how strongly differences among individuals for a trait are related to differences among their genes.

One reason nature–nurture continues to fascinate us so much is that we live in an era of great scientific discovery in genetics, comparable to the times of Copernicus, Galileo, and Newton, with regard to astronomy and physics. Every day, it seems, new discoveries are made, new possibilities proposed. When Francis Galton first started thinking about nature–nurture in the late-19th century he was very influenced by his cousin, Charles Darwin, but genetics per se was unknown.

Mendel's famous work with peas, conducted at about the same time, went undiscovered for 20 years; quantitative genetics was developed in the 1920s; DNA was discovered by Watson and Crick in the 1950s;

the human genome was completely sequenced at the turn of the 21st century; and we are now on the verge of being able to obtain the specific DNA sequence of anyone at a relatively low cost. No one knows what this new genetic knowledge will mean for the study of nature–nurture, but as we will see in the next section, answers to nature–nurture questions have turned out to be far more difficult and mysterious than anyone imagined.

About Nature–Nurture

It would be satisfying to be able to say that nature–nurture studies have given us conclusive and complete evidence about where traits come from, with some traits clearly resulting from genetics and others almost entirely from environmental factors, such as

childrearing practices and personal will; but that is not the case. Instead, everything has turned out to have some footing in genetics. The more genetically-related people are, the more similar they are—for everything: height, weight, intelligence, personality, mental illness, etc. Sure, it seems like common sense that some traits have a genetic bias. For example, adopted children resemble their biological parents even if they have never met them, and identical twins are more similar to each other than are fraternal twins.

And while certain psychological traits, such as personality or mental illness (e.g., schizophrenia), seem reasonably influenced by genetics, it turns out that the same is true for political attitudes, how much television people watch (Plomin, Corley, DeFries, & Fulker, 1990), and whether or not they get divorced (McGue & Lykken, 1992).

It may seem surprising, but genetic influence on behavior is a relatively recent discovery. In the middle of the 20th century, psychology was dominated by the doctrine of behaviorism, which held that behavior could only be explained in terms of environmental factors. Psychiatry concentrated on psychoanalysis, which probed for roots of behavior in individuals' early life-histories. The truth is, neither behaviorism nor psychoanalysis is incompatible with genetic influences on behavior, and neither Freud nor Skinner was naive about the importance of organic processes in behavior. Nevertheless, in their day it was widely thought that children's personalities were shaped entirely by imitating their parents' behavior, and that schizophrenia was caused by certain kinds of "pathological mothering."

Whatever the outcome of our broader discussion of nature–nurture, the basic fact that the best predictors of an adopted child's personality or mental health are found in the biological parents he or

she has never met, rather than in the adoptive parents who raised him or her, presents a significant challenge to purely environmental explanations of personality or psychopathology. The message is clear: You can't leave genes out of the equation. But keep in mind, no behavioral traits are completely inherited, so you can't leave the environment out altogether, either.

Trying to untangle the various ways nature-nurture influences human behavior can be messy, and often common-sense notions can get in the way of good science. One very significant contribution of behavioral genetics that has changed psychology for good can be very helpful to keep in mind: When your subjects are biologically-related, no matter how clearly a situation may seem to point to environmental influence, it is never safe to interpret a behavior as wholly the result of nurture without further evidence.

For example, when presented with data showing that children whose mothers read to them often are likely to have better reading scores in third grade, it is tempting to conclude that reading to your kids out loud is important to success in school; this may well be true, but the study as described is inconclusive, because there are genetic as well as environmental pathways between the parenting practices of mothers and the abilities of their children. This is a case where "correlation does not imply causation," as they say.

To establish that reading aloud causes success, a scientist can either study the problem in adoptive families (in which the genetic pathway is absent) or by finding a way to randomly assign children to oral reading conditions.

Psychological researchers study genetics in order to better understand the biological basis that contributes to certain behaviors. While all humans share certain biological mechanisms, we are each

unique. And while our bodies have many of the same parts—brains and hormones and cells with genetic codes—these are expressed in a wide variety of behaviors, thoughts, and reactions.

Why do two people infected by the same disease have different outcomes: one surviving and one succumbing to the ailment? How are genetic diseases passed through family lines? Are there genetic components to psychological disorders, such as depression or schizophrenia? To what extent might there be a psychological basis to health conditions such as childhood obesity?

To explore these questions, let's start by focusing on a specific disease, sickle-cell anemia, and how it might affect two infected sisters. **Sickle-cell anemia** is a genetic condition in which red blood cells, which are normally round, take on a crescent-like shape (Figure 5). The changed shape of these cells affects how they function: sickle-shaped cells can clog blood vessels and block blood flow, leading to high fever, severe pain, swelling, and tissue damage.

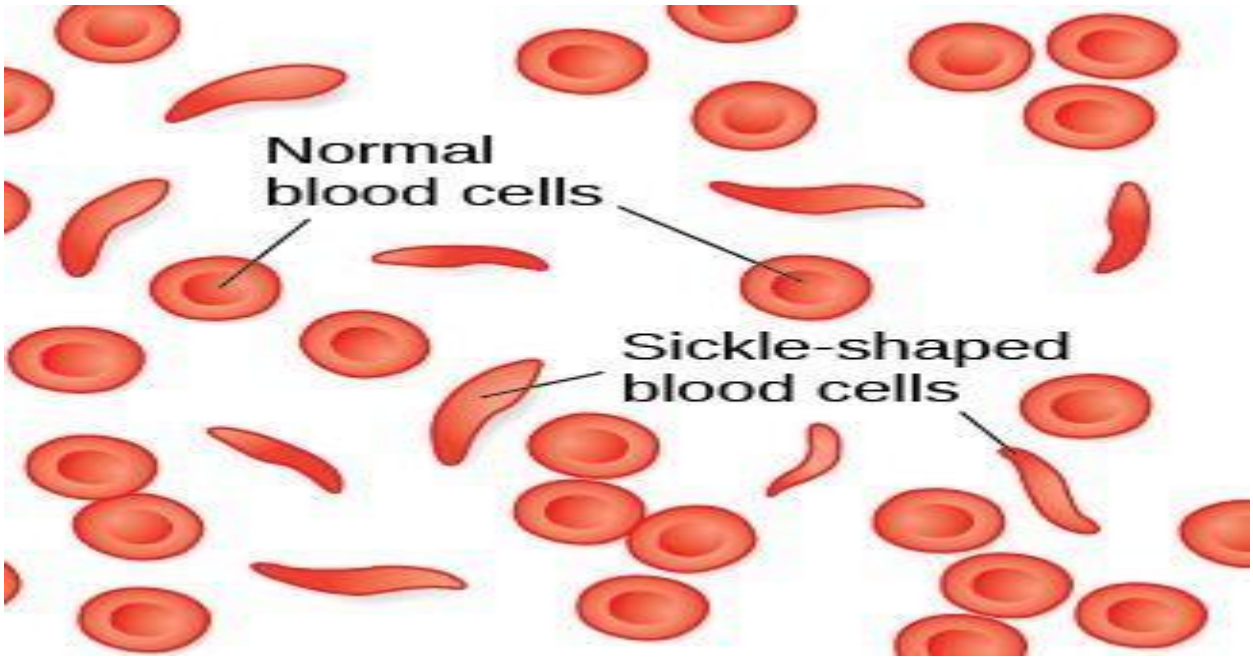


Figure 5. Normal blood cells travel freely through the blood vessels, while sickle-shaped cells form blockages preventing blood flow.

Many people with sickle-cell anemia—and the particular genetic mutation that causes it—die at an early age. While the notion of "survival of the fittest" may suggest that people suffering from this disease have a low survival rate and therefore the disease will become less common, this is not the case. Despite the negative evolutionary effects associated with this genetic mutation, the sickle-cell gene remains relatively common among people of African descent. Why is this? The explanation is illustrated with the following scenario.

Imagine two young women—Luwi and Sena—sisters in rural Zambia, Africa. Luwi carries the gene for sickle-cell anemia; Sena does not carry the gene. Sickle-cell carriers have one copy of the sickle-cell gene but do not have full-blown sickle-cell anemia. They experience symptoms only if they are severely dehydrated or are deprived of oxygen (as in mountain climbing).

Carriers are thought to be immune from malaria (an often deadly disease that is widespread in tropical climates) because changes in their blood chemistry and immune functioning prevent the malaria parasite from having its effects (Gong, Parikh, Rosenthal, & Greenhouse, 2013). However, full-blown sickle-cell anemia, with two copies of the sickle-cell gene, does not provide immunity to malaria.

UNIT-4 Biological basis of behavior MCQs

DIWAKAR EDUCATION HUB

1) Higher motor commands originate in all the following centers, except :-
a- cerebral cortex
b- thalamus
c- caudate nucleus
d- cerebellum
Ans:- B

2) A reflex action :-
a- is a fast brief response to a sensory stimulus
b- is involved in regulation of voluntary movements
c- includes at least three sequential sets of neurons in its pathway
d- is always initiated whenever its specific receptors are effectively stimulated by a specific stimulus
Ans:- D

3) Reflex actions could be classified according to :-
a- the type of sensory receptors initiating them
b- the type of afferent nerves mediating them
c- the type of efferent nerves mediating them
d- the type of neurotransmitters mediating them
Ans:- C

4) Events of reflex actions include all the following, except :-
a- stimulation of sensory receptors
b- stimulation of central synapses
c- inhibition of sensory receptors
d- inhibition of central synapses
Ans:- C

5) A reflex arc includes :-
a- at least two sets of sequential neurons
b- at least two sequential sets of central synapses
c- at least two types of sensory receptors
d- at least two types of efferent neurons
Ans:- A

6) The central terminals of afferent neurons mediating spinal reflexes are distributed within the spinal cord, so that :-
a- all of them terminate in the same spinal segment of their entry to the cord
b- all of them terminate on interneurons
c- all of them subserve spinal reflexes

d- they provide pathways for divergence of the incoming sensory impulses
Ans:- D

7) Interneurons :-
a- provide communication between the central ends of afferent neurons
b- provide communication between dendrites of the efferent neurons
c- influence the rate of discharge from the alpha motor neurons
d- participate in ascending sensory pathways
Ans:- C

8) The divergence function of interneurons is involved in :-
a- temporal summation
b- spatial summation
c- reverberation
d- irradiation
Ans:- D

9) Interneuron after-discharge circuits prolong the duration of :-
a- sensory input to the spinal motor centers
b- synaptic delay in central synapses
c- discharge of efferent neurons
d- conscious perception of the evoked sensation
Ans:- C

10) A flexor withdrawal reflex shows all the following properties, except :-
a- recruitment
b- prepotent
c- non-fatigable
d- irradiation
Ans:- C

11) Flexor reflexes do not involve :-
a- flexor muscles
b- extensor muscles
c- reciprocal inhibition
d- reflex spasm of the involved muscles
Ans:- D

12) The ability of stronger stimuli to produce wider range of reflex responses depends upon :-
a- presence of reverberating circuits in reflex pathway
b- presence of parallel-chain circuits in reflex pathway
c- convergence of interneurons
d- divergence of interneurons
Ans:- D

13) Recruitment of a reflex response is due to :-

a- difference in the amount of presynaptic inputs to the various efferent neurons initiating the reflex
b- difference in the conduction velocity of the various afferent neurons mediating the reflex
c- delay at the neuromuscular junction
d- presence of inhibitory interneurons in the reflex pathway
Ans:- A

14) After-discharge of reflex responses :-
a- increase the magnitude of the reflex responses
b- delays the onset of fatigue of reflex responses
c- involves interneuron circuits
d- depends upon spatial summation
Ans:- C

15) Central delay of reflex actions :-
a- is due to presence of inhibitory interneurons in the reflex pathway
b- is the time between stimulation of receptors and response of the effector muscle
c- is longer in the flexor reflex than in the stretch reflex
d- is determined by the velocity of conduction of impulses along the afferent and efferent neurons in the reflex pathway
Ans:- C

16) Fatigue of reflexes :-
a- develops gradually and recovers rapidly
b- develops rapidly and recovers slowly
c- develops gradually and recovers slowly
d- develops rapidly and recovers rapidly
Ans:- C

17) In flexor withdrawal reflexes contraction of flexor muscles is associated with reciprocal inhibition of :-
a- synergistic flexor muscles
b- contralateral extensor muscles
c- ipsilateral extensor muscles
d- both 'a' and 'b' are correct
Ans:- C

18) Reciprocal inhibition between reflexes depends upon all the following, except :-
a- presence of inhibitory interneurons in the reflex pathways
b- presence of excitatory interneurons in the reflex pathways

c- presence of anion channels in membranes of the involved neurons
d- release of inhibitory transmitters which block cation channels in the reflex pathways
Ans:- D

19) stretch reflex is characterized by the following except :-
a- disynaptic reflex
b- high localization
c- shows reciprocal innervations.
d- it is of graded response
Ans:- A

20) Stretch of an innervated muscle evokes :-
a- contraction of its spindles
b- contraction of its extrafusal fibers
c- contraction of antagonistic muscles
d- relaxation of synergistic muscles
Ans:- B

21) Muscle spindles :-
a- are found in all skeletal muscles
b- are found only in large skeletal muscles
c- consist of small numbers of extrafusal muscle fibers
d- consist of a large number of extrafusal muscle fibers
Ans:- A

22) The nuclear-bag fibers of muscle spindles are innervated by :-
a- Aγ nerve fibers
b- Aβ nerve fibers
c- Aδ nerve fibers
d- Ia nerve fibers
Ans:- D

23) The nuclear-chain fibers of spindles are innervated by :-
a- Aα and Aδ nerve fibers
b- Aδ and C nerve fibers
c- Ia and II nerve fibers
d- only type II nerve fibers
Ans:- C

24) The central ends of afferents from muscle spindles synapse with all the following types of neurons, except :-
a- α-motor neurons of the same muscle
b- γ-motor neurons of the same muscle
c- local interneurons
d- 2 nd order neurons of ascending sensory pathways
Ans:- B

25) γ-motor innervation of muscle spindles produces :-
a- contraction of the central region of the spindle fibers
b- increased sensory discharge from the central region of the spindle fibers
c- decreased sensory discharge from the central region of the spindle fibers
d- relaxation of the peripheral regions of the spindle fibers
Ans:- B

26) Discharge from muscle spindles could be increased by all the following, except :-
a- increased α-motor neuron discharge
b- increased γ-motor neuron discharge
c- stretch of the intrafusal muscle fibers
d- stretch of the extrafusal muscle fibers
Ans:- A

27) Increased γ-motor neuron discharge stimulates muscle spindles, because :-
a- it produces stretch of the extrafusal muscle fibers
b- it causes stretch of the peripheral regions of the intrafusal fibers
c- it causes stretch of the central region of the intrafusal fibers
d- it stimulates directly the sensory fibers innervating muscle spindles
Ans:- C

28) γ-motor neuron discharge to a muscle is inhibited by impulses reaching the γ-motor neurons from all the following source, except :-
a- Golgi tendon organs of the same muscle
b- spindles of antagonistic muscles
c- medullary reticular formation
d- pontine reticular formation
Ans:- D

29) When the γ-motor neuron discharge to a muscle decreases, it causes :-
a- increased muscle spindle discharge
b- shortening of the spindle fibers
c- stronger contraction of the extrafusal muscle fibers
d- decreased spindle sensitivity to stretch
Ans:- D

30) The role of muscle spindles in the maintenance of the upright posture depends upon all the following, except :-
a- contraction of the peripheral contractile part of spindle fibers
b- increased sensory discharge from spindles of postural muscles
c- increased supraspinal facilitation to the γ-motor neurons of postural muscles
d- presence of greater numbers of spindles in postural muscles
Ans:- D

31) The role of γ-motor neurons in regulation of equilibrium is achieved by :-
a- initiating contraction of spindle fibers which directly antagonize postural deviation
b- increasing spindle sensitivity to stretch
c- directly stimulating extrafusal muscle fibers to antagonize postural deviation
d- directly adjusting the discharge of α-motor neurons innervating the extrafusal muscle fibers to antagonize postural deviation
Ans:- B

32) interruption of γ-motor neuron discharge to a skeletal muscle produces :-
a- contraction of the muscle
b- contraction of the spindle fibers
c- relaxation of the spindle fibers
d- increased sensory discharge from the spindle fibers
Ans:- C

33) Co-activation of α and γ-motor neurons :-
a- increases γ-motor neuron discharge whenever the activity of α-motor neurons rises to a high level
b- is mediated by interneurons that link the α and γ-motor neurons
c- maintains the proprioceptive information to higher centers during muscle contraction
d- increases the α-motor neuron discharge whenever the activity of γ-motor neurons rises to a high level
Ans:- C

34) Increased sensory discharge from muscle spindles :-
a- decreases muscle tone
b- increases muscle tone
c- could either increase or decrease muscle tone according to the muscle affected

d- has no effect on muscle tone
Ans:- C

35) Interruption of spindle discharge from a muscle causes contraction of the muscle to become jerky and irregular due to :-
a- increased activity of reverberating circuits causing fluctuation of the motor discharge to the muscle
b- increased activity of inhibitory interneurons causing oscillating inhibition of the α-motor neurons of the muscle
c- irregular discharge of excitatory inputs to the α-motor neurons of the muscle
d- post-tetanic potentiation of the α-motor neurons of the muscle
Ans:- C

36) Whenever the position of a joint is stabilized at a certain attitude, the nervous system produces this by :-
a- increasing the α-motor neuron discharge to all muscles attached to the joint
b- increasing the γ-motor neuron discharge to all muscles attached to the joint
c- increasing γ-motor neuron discharge to postural muscles
d- co-activation of α and γ-motor neurons innervating the involved muscles
Ans:- D

37) The highly localized nature of stretch reflex is due to :-
a- the limited number of interneurons in the reflex pathway
b- all the central ends of afferents from spindles of the stretched muscle terminate on the α -motor neurons of the muscle
c- the α -motor neurons of the stretched muscle receive most of the central terminals of afferents coming from spindles of the muscle
d- activation of inhibitory interneurons which inhibit the motor neurons of the surrounding muscles
Ans:- C

38) The shortest reflex time is recorded with :-
a- a flexor withdrawal reflex
b-an inverse stretch reflex
c- a stretch reflex
d- a scratch reflex
Ans:- C

39) When a skeletal muscle is suddenly stretched :-
a- it relaxes suddenly
b- it develops a static stretch reflex
c- it develops a dynamic stretch reflex
d- it develops clonic contractions
Ans:- C

40) Sensory impulses from spindles of a stretched muscle could inhibit antagonistic muscles by :-
a- directly inhibiting γ-motor neurons of the antagonistic muscles
b- directly inhibiting the α -motor neurons of the antagonistic muscles
c- inhibiting the transmitter release from the central terminals of afferents from the spindles of the antagonistic muscles
d- activation of inhibitory interneurons
Ans:- D

41) Antigarvity muscles maintain stretch reflex for prolonged periods without fatigue, because :-
a- they are heavily innervated by α -motor neurons
b- they obtain their energy needs mainly from anaerobic metabolic processes
c- they contain exceptionally high levels of creatine phosphate
d- they are rich in mitochondria
Ans:- D

42) The discharge from Golgi tendon organs initiated by excessive stretch of a skeletal muscle produces :-
a- inhibition of α -motor neurons of antagonistic muscles
b- inhibition of γ-motor neurons of antagonistic muscles
c- inhibition of α -motor neurons of the same muscle
d- stimulation of γ-motor neurons of the same muscle
Ans:- C

43) Inverse stretch reflex :-
a- increases the possibility of avulsion of the excessively stretched muscle from its bony attachments
b- has no reciprocal innervation circuits
c- is clinically manifested by lengthening reaction
d- is clinically tested by examining the tendon jerks
Ans:- C

44) Skeletal muscle tone :-
a- is a dynamic stretch reflex

b- has a dynamic state
c- is increased during rest
d- is decreased during standing upright
Ans:- B

45) γ-motor neurons control muscle tone by :-
a- adjusting the supraspinal facilitatory discharge
b- adjusting the α -motor neuron discharge
c- adjusting the muscle spindle discharge
d- adjusting the activity of interneurons in the reflex arc of muscle tone
Ans:- C

46) Adequate level of muscle tone is essential for the accurate performance of voluntary movements, because :-
a- it adjusts the α -motor neuron discharge initiating voluntary movements
b- it adjusts posture of proximal joints of the acting limbs
c- it adjusts the upright posture of the whole body during voluntary movements
d- it adjusts sensitivity of the spindles of the involved muscles
Ans:- B

47) A tendon jerk :-
a- is a dynamic stretch reflex
b- is a static stretch reflex
c- is evoked by gradually stretching the muscle
d- is evoked by stimulation of tendon receptors
Ans:- A

48) The tendon jerk which has its center in the 5th and 6th cervical segments of the spinal cord is :-
a- the jaw jerk
b- the deltoid jerk
c- the biceps jerk
d- the triceps jerk
Ans:- C

49) Tendon jerks are clinically examined to asses :-
a- integrity of muscle spindles
b- integrity of reflex pathway
c- the total reflex time of the jerk
d- central delay time of the jerk
Ans:- B

50) Absence of a tendon jerk could result from any of the following conditions, except :-
a- lesions of supraspinal facilitatory centers
b- lesions of the efferent neurons
c- lesions of the afferent neurons
d- lesions of the spinal nerve centers
Ans:- A

51) Exaggeration of tendon jerks could result from any of the following conditions, except :-
a- lesions of supraspinal facilitatory centers
b- lesions of supraspinal inhibitory centers
c- increased γ-motor neuron discharge
d- anxiety
Ans:- A

52) Clonus :-
a- is a sign of decreased supraspinal facilitation
b- initiated by briefly stretching the tendon of the muscle
c- is manifested as oscillating mechanical vibrations following tendon jerks
d- associates exaggeration of tendon jerks
Ans:- D

53) The central nervous system includes all the following components, except :-
a- spinal cord
b- medulla oblongata
c- autonomic ganglia
d- diencephalon
Ans:- C

54) The central nervous system is connected with the peripheral nervous system by all the following types of nerve fibers, except :-
a- postganglionic autonomic fibers
b- preganglionic autonomic fibers
c- somatic motor fibers
d- autonomic sensory fibers
Ans:- A

55) The sensory system is involved in all the following, except :-
a- initiation of reflex movements
b- initiation of voluntary movements
c- learning processes
d- initiation of emotional responses
Ans:- B

56) The two-element sensory receptors differ from other types of receptors in being:-

a- more numerous
b- more widely spread in the body
c- more sensitive
d- composed of specialized cells at the sensory nerve terminals
Ans:- D

57) Sensory receptors are classified functionally according to the following criteria, except :-
a- their location in the body
b- the nature of tissues in which they are found
c- the nature of stimuli acting on them
d- their connection with cerebral coretx
Ans:- A

58) Most sensory receptors :-
a- are stimulated by different types of stimuli
b- are stimulated only by specific stimuli
c- posses a high threshold for their specific stimuli
d- only 'b' and 'c' are correct
Ans:- B

59) A specific stimulus produces a receptor potential by :-
a- inhibiting Na + influx into receptor
b- inhibiting K + efflux from receptor
c- enhancing Na + influx into receptor
d- enhancing K + efflux from receptor
Ans:- C

60) Receptor potential initiated by an adequate stimulus :-
a- develops always at it full magnitudes
b- undergoes temporal summation only
c- undergoes spatial summation only
d- could initiate an action potential
Ans:- D

61) Once initiated, the receptor potential :-
a- spreads to a long distance along the sensory nerve fiber
b- amplitude is not related to the strength of the stimulus
c- always generates an action potential from the receptor
d- stays for a variable period depending on the type of the receptor
Ans:- D

62) Receptor potential generates :-

a- an electrotonic current which is transmitted along sensory fibers to the CNS
b- a nerve impulse at the receptive region of the receptor
c- a state of hyperpolarization of the receptor membrane
d- a nerve impulse at the spike initiating region of the receptor
Ans:- D

63) When stimulated by effective steady stimuli, sensory receptors :-
a- continuously discharge impulses
b- stop discharging after a short time
c- produce an initial high rate of impulse discharge followed by decline of this rate
d- differ in their response ; some types discharge continuously, while other types do not respond at all
Ans:- C

64) Slowly adapting receptors include all the following types, except :-
a- Golgi tendon organs
b- warmth receptors
c- free nerve endings
d- Meissner corpuscles
Ans:- D

65) Slowly adapting receptors differ from rapidly adapting receptors in :-
a- stopping to discharge after a relatively longer period of constant stimulation
b- detecting the dynamic properties of stimuli
c- detecting velocity of stimuli
d- generating receptor potentials as long as stimulus is applied.
Ans:- D

66) Rapidly adapting receptors are involved in :-
a- static reflex responses
b- detection of joint movements
c- regulation of heart rate
d- only 'a' and 'b' are correct
Ans:- B

67) Receptors detect stimulus intensity by :-
a- lowering the threshold for receptor stimulation
b- by generating receptor potentials having higher magnitudes
c- by generating nerve impulses that are transmitted along sensory fibers at higher velocities
d- by enhancing the central effects of sensory impulses
Ans:- B

68) General sensations :-
a- originate from all sensory receptors of the body
b- are mediated by somatic sensory fibers only
c- include the sense of movement
d- include the sense of equilibrium
Ans:- C

69) Detection of the stimulus modality depends upon :-
a- the location of the receptors in the body
b- the magnitude of the stimulus
c- the anatomical connections between the receptors and specific sensory areas in the cerebral cortex
d- the magnitude of the receptor potential
Ans:- C

70) Receptors detect stimulus intensity by :-
a- lowering the threshold for stimulating receptors b- raising the threshold for stimulating receptors
c- decreasing the magnitude of receptor potential d- raising the magnitude of receptor potential
Ans:- D

71) The ability to localize the site of stimuli depends upon :-
a- the type of the stimulated receptor
b- connections between the receptor and the sensory cortex
c- the rate of adaptation of the stimulated receptors
d- the nature of the stimulus
Ans:- B

72) Touch receptors :-
a- are found only in the skin
b- are all encapsulated receptors
c- include two-element receptors
d- are stimulated by vibration
Ans:- D

73) Rapidly adapting tactile receptors include all the following types, except :-
a- Merkel discs
b- Meissner corpuscles
c- Pacinian corpuscles
d- hair end organs
Ans:- A

74) Fine touch :-
a- is detected by slowly adapting touch receptors b- is transmitted by the spinothalamic tract

c- is characterized by it emotional affect
d- is not involved in feeling the texture of touched objects
Ans:- A

75) Crude touch is more effective than fine touch in evoking an emotional response because :-
a- its provoking stimuli are stronger
b- its central pathway connects with the limbic system
c- it is stimulated during emotional excitement
d- the provoking stimuli have an emotional nature
Ans:- B

76) A more developed two-point tactile discrimination :-
a- indicates a greater threshold distance for feeling of two points of touch applied simultaneously
b- is seen in the proximal regions of the body compared with the distal regions
c- is inversely related to the size of the receptive fields of the stimulated sensory units
d- depends upon the type of the involved touch receptor
Ans:- C

77) Proprioceptive sensations include all the following, except :-
a- position sense
b- equilibrium sense c- movement sense d- kinesthetic sense
Ans:- B

78) Proprioceptors include all the following types of receptors, except :-
a- muscle spindles
b- pressure receptors
c- vestibular receptors
d- joint receptors
Ans:- C

7 9) Proprioceptive sensations are transmitted by all the following pathways, except :-
a- spinothalamic tracts
b- spinocerebellar tract
c- gracile tract
d- cuneocerebellar tract
Ans:- A

80) Astereognosis :-
a- indicates inability to localize the site of touch on the body surface
b- results from lesions of the secondary somatic sensory area
c- associates parietal lobe neglect

d- results from loss of crude touch sensation
Ans:- C

81) Parietal lobe neglect :-
a- is characterized by inability to use skeletal muscles on the opposite side of the body
b- is characterized by inability to use skeletal muscles on the same side of the body
c- results from damage of primary sensory cortex.
d- causes loss of sensations on the same side of the body
Ans:- A

82) Tactile receptors include all the following receptors, except :-
a- free nerve endings
b- hair follicle receptors
c- hair cell receptors
d- Ruffini nerve endings
Ans:- C

83) Pain receptors :-
a- become more sensitive with prolonged stimulation
b- are stimulated by prostaglandins
c- are more numerous in viscera than other tissues
d- include different morphological types
Ans:- A

84) Pain threshold :-
a- is the highest intensity of stimulus that causes pain
b- is the lowest intensity of stimulus that causes pain
c- differs markedly among different individuals
d- is elevated by substance P
Ans:- B

85) Fast pain differs from slow pain in :-
a- being transmitted in the dorsal column pathway
b- evoking a depressor autonomic reaction
c- having a sharp quality
d- arising from encapsulated pain receptors
Ans:- C

86) Double pain sensation that is occasionally felt following painful stimulation of the skin is due to :-
a- repetition of the painful stimulus
b- presence of dual pain pathways
c- perception of pain at two different higher centers

d- application of two painful stimuli simultaneously at two different sites
Ans:- B

87) Cutaneous pain :-
a- is always sharp in character
b- is transmitted by Aδ sensory fibers
c- is always followed by hyperalgesia
d- evokes spasm of nearby muscles
Ans:- B

88) Primary cutaneous hyperalgesia :- a- develops in the normal skin region around the area of flare
b- is an abnormal condition in the skin in which painful stimuli become more severe
c- is due to changes in threshold of pain receptors
d- is associated with throbbing type of pain
Ans:- C

89) Deep pain shows the following characteristics, except :-
a- dull aching
b- throbbing
c- evokes flexor reflexes
d- diffuse
Ans:- C

90) Intermittent Claudications evoke :- a- visceral pain
b- deep pain
c- cutaneous hyperalgesia
d- colicky pain
Ans:- B

91) Pain sensation :-
a- is evoked by strong stimulation of specific receptors
b- produces reactions that block transmission of pain impulses
c- arises from small encapsulated receptors
d- occurs when the stimulus causes damage of the sensory receptors
Ans:- A

92) Reaction to pain includes all the following, except :-
a- increased heart rate
b- depression
c- withdrawal reflexes
d- stoppage of impulse discharge from nociceptors in chronic painful conditions
Ans:- D

93) Pain produced by muscle spasm results from :-
a- mechanical stimulation of pain receptor by muscle spasm

b- decreased release of lactic acid from the spastic muscle fibers
c- release of compounds from the spastic muscle which increase the threshold for stimulation of pain receptors
d- decreased oxygen supply to the muscle
Ans:- D

94) Visceral pain :-
a- is more common than the other types of pain
b- arises only from wall of the visceral organs
c- is often well localized
d- evokes depressor autonomic reactions
Ans:- D

95) Stimuli which evoke true visceral pain include all the following, except :-
a- sharp cutting
b- stretching
c- spasm
d- chemical irritation
Ans:- A

96) Visceral pain is usually felt :-
a- deeply in the diseased viscera
b- in deep tissues close to the diseased viscera
c- in skin areas that just overlie the diseased viscera
d- in skin areas remote from the diseased viscera
Ans:- D

97) Intracranial headache could result from painful stimuli applied on :-
a- the dura lining the inner surface of the bones of cranial vault
b- the brain tissue
c- wall of big intracranial veins
d- arachnoid mater
Ans:- C

98) Intracranial headache may result from all the following clinical causes, except :-
a- decreased CSF pressure
b- spasm of scalp muscles
c- distension of big venous sinuses
d- pressure upon tentorium cerebelli
Ans:- B

99) Transmitters in pain control system include all the following, except :-
a- serotonin
b- acetylcholine

c- enkephalin
d- norepinephrine
Ans:- B

100) Enkephalin binds best with :-
a- delta 'δ' opiate receptors
b- muta 'μ' opiate receptors
c- kappa 'κ' opiate receptors
d- all opiate receptors with equal affinity
Ans:- A

101) Pain control system :-
a- is activated whenever a painful stimulus is applied to body tissues
b- is never activated naturally
c- is activated only by administration of opiate drugs
d- is activated naturally under conditions associated with strong emotional excitement
Ans:- D

102) Enkephalin blocks pain transmission by :-
a- blocking the response of pain receptors to painful stimuli
b- slowing down transmission of pain impulses through synapses in the pain pathway
c- inhibiting the response of the cerebral cortical somatic sensory area to pain signals
d- blocking Ca ++ channels in the central terminals of pain sensory fibers
Ans:- D

103) The spinal pain gate is :-
a- Ligand controlled
b- voltage controlled
c- opened by enkephalin
d- closed by substance P
Ans:- A

104) Thermal sensations :-
a- are evoked by all changes in environmental temperatures
b- are evoked by stimulation of thermo-sensitive pain receptors
c- are involved in regulation of metabolic activity
d- are transmitted by Aβ sensory fibers
Ans:- C

105) Thermal receptors are :-
a- slowly adapting receptors
b- rapidly adapting receptors
c- biphasic receptors
d- all encapsulated receptors
Ans:- A

106) Connexons of gap junctions in electric synapses :-
a- are Ligand-gated
b- are voltage-gated
c- allow transmission of potential changes in both directions between the pre- and post- synaptic neurons
d- close whenever the presynaptic neuron becomes hyperpolarized
Ans:- C

107) Chemical synapses in the nervous system :-
a- allow diffusion of chemical substances form the presynaptic neuron into the postsynaptic neuron
b- allow transmission of potential changes in one direction only; from the presynaptic to the postsynaptic neurons
c- have potential-gated ionic channels
d- are more numerous in the peripheral nervous system than the central nervous system
Ans:- B

108) Synaptic cleft :-
a- is the space between two synapses on the surface of neurons
b- allow diffusion of transmitters between neurons
c- is filled with intracellular fluid
d- ranges between 20 – 30 µm in width
Ans:- B

109) Synaptic knobs :-
a- synthesize different types of neurotransmitters
b- release neurotransmitters by diffusion across their membranes
c- have ligand-gated Ca ++
d- are located at the terminal end of dendrites
Ans:- A

110) Synaptic transmission depends upon :-
a-direct transmission of impulses from the presynaptic neuron to the postsynaptic neuron
b- diffusion of neurotransmitters from synaptic knobs into the soma and dendrites of postsynaptic neurons
c- presence of voltage-gated Ca ++ channels in membrane of synaptic knobs
d- presence of voltage-gated Ca ++ channels in the subsynaptic membrane

Ans:- C

111) Postsynaptic receptors include all the following types, except :-
a- G-protein coupled receptors
b- ligand-gated cation channels
c- G-protein regulated K + channels
d- voltage-gated Cl- channels
Ans:- D

112) When opened, the ligand-gated cation channels do not allow diffusion of Cl- because :-
a- the size of Cl- is bigger than the bore of the channels
b- intracellular negativity causes complete inhibition of Cl- influx
c- the channels are specific for diffusion of Na + only
d- the inner surface of the channels is negatively charged
Ans:- D

113) Opening of ligand-gated Cl- channels causes :-
a- inhibition of the postsynaptic neuron
b- depolarization of the postsynaptic neuron
c- initiation of an action potential d- block of ligan
d-gated cation channels

Ans:- A

114) IPSP differs from EPSP in :-
a- being of shorter duration
b- being unable o summate spatially
c- moving the membrane potential away from threshold
d- depending upon opening of voltage K + channels
Ans:- C

115) When EPSP and IPSP occur simultaneously the postsynaptic membrane :-
a- becomes depolarized
b- becomes hyperpolarized
c- initiates an action potential
d- shows potential changes that depend upon the summation of their effects
Ans:- D

116) When a postsynaptic neuron is adequately stimulated, action potentials develop at the initial segment of the axon because :-
a- it contains many voltage-gated Na + channels
b- it contains the highest concentration of ligand-gated cation channels

c- it contains many voltage-gated Ca ++ channels
d- it is more sensitive to the direct stimulant effect of neurotransmitters
Ans:- A

117) IPSP could result from :-
a- opening of K + channels
b- opening of ligand-gated cation channels
c- closure of Cl- channels
d- closure of potential-gated Ca ++ channels
Ans:- A

118) Synaptic transmission s terminated by :-
a- block of pretsynaptic receptors
b- elevation of Ca ++ concentration in synaptic cleft
c- reuptake of neurotransmitters by postsynaptic neurons
d- degradation of neurotransmitters by specific enzymes
Ans:- D

119) Presynaptic inhibition is characterized by all the following, except :-
a- increased Cl- influx into presynaptic terminals
b- increased Ca ++ influx into presynaptic terminals
c- decreased response of postsynaptic receptors
d- hyperpolarization of presynaptic terminals
Ans:- B

120) Presynaptic inhibition depends upon :-
a- augmented release of chemical transmitter from presynaptic terminals
b- continued depolarization of presynaptic terminals
c- GABA receptors in presynaptic terminals
d- opening of voltage-gated Ca ++ channels in presynaptic terminals
Ans:- C

121) In chemical synapses, transmission occurs in a forward direction because :-
a- neurotransmitter receptors are found only in the postsynaptic membrane
b- the subsynaptic membrane does not contain neurotransmitter vesicles
c- the subsynaptic membrane is more sensitive than the membrane

of synaptic knob to the effect of neurotransmitters
d- the subsynaptic membrane contains both ligand-gated and voltage-gated ionic channels
Ans:- B

122) Synaptic delay :-
a- is the time needed for release of neurotransmitter from synaptic vesicles
b- the minimal delay time in the central nervous system is about 0.5 millisecond
c- is determined by the type of the neurotransmitter
d- is determined by the number of postsynaptic receptors

Ans:- B

123) Synaptic fatigue is due to : -
a- decreased synthesis of neurotransmitters
b- inability to release neurotransmitters by exocytosis
c- failure of action potentials to open voltage-gated Ca ++ channels in presynaptic terminal
d- imbalance in between rates of synthesis and release of neurotransmitters

Ans:- D

124) Synaptic transmission is inhibited by all the following, except :-
a- oxygen lack
b- alkalosis
c- acidosis
d- prolonged activity of synapse
Ans:- B

125) Post-tetanic Potentiation in synapses :-
a- is due to increased Ca ++ concentration in postsynaptic neurons
b- is due to increased Ca ++ influx into presynaptic neurons
c- results from slow prolonged stimulation of synapse
d- causes fatigue of the synapse
Ans:- B

126) Long-term potentiation of synaptic transmission :-
a- is involved in pain control system
b- is caused by increased Ca ++ concentration in presynaptic neurons
c- results from fast repetitive stimulation of synapse

d- is associated with decreased Ca ++ concentration in postsynaptic neurons
Ans:- C

127) Drugs which open Cl- channels in synapses :-
a- cause depolarization of postsynaptic membrane
b- cause hyperpolarization of postsynaptic membrane
c- enhance release of neurotransmitters from synaptic knobs
d- enhance response of postsynaptic neurons
Ans:- B

128) Small-molecule neurotransmitters include all the following types, except :-
a- Substance P
b- gamma amino butyric acid
c- acetylcholine
d- norepinephrine
Ans:- A

129) Neuropeptides :-
a- are synthesized in the synaptic knobs
b- consist of small molecules
c- interact with ligand-receptors
d- could produce prolonged changes in the structure of postsynaptic neurons
Ans:- D

130) All the following transmitters are neuropeptides, except :-
a- neuropeptide Y
b- somatostatin
c- dopamine
d- enkephalin
Ans:- C

131) Actions of neuropeptides include all the following, except :-
a- inhibition of gene transcription
b- decreased cyclic AMP synthesis
c- changing intracellular Ca ++ level
d- activation of ligand-gated receptors
Ans:- D

132. What part of a neuron is responsible for receiving information?
a. axon
b. terminal fibre
c. dendrite
d. myelin sheath
Ans:- C

133. Electrical stimulation of the reticular formation would most likely cause an animal to:
a. sneeze
b. become blind
c. wake up if it had been sleeping
d. stop breathing

Ans:- C

134. In evolutionary terms, which is the oldest part of the brain?
a. the limbic system
b. the cortex
c. the right hemisphere
d. the brain stem

Ans:- D

135. The change in electrical charge that occurs in a neuron when a nerve impulse is transmitted is known as the:
a. action potential
b. synaptic change
c. refractory period
d. ionic charge

Ans:- A

136. Schizophrenia and Parkinson's disease are both linked to changes in which neurotransmitter?
a. serotonin
b. glutamate
c. dopamine
d. acetylcholine

Ans:- C

137. The limbic system includes the:
a. amygdala, hypothalamus, hippocampus
b. hypothalamus, medulla, hippocampus
c. hippocampus, pons, thalamus
d. cerebellum, pons, hypothalamus

Ans:- A

138. The_____is to feeling fear as the_____is to feeling pleasure.
a. pons/medulla
b. amygdala/hypothalamus
c. thalamus/hypothalamus
d. cerebellum/amygdale

Ans:- B

139. The effect of neurotransmitters may be:
a. chemical or electrical
b. excitatory or inhibitory
c. positive or negative
d. active or passive

Ans:- B

140. The terminal buttons of a neuron are located at the end of its:
a. axon
b. dendrite
c. myelin sheath
d. nodes of ranvier

Ans:- A

141. Which lobe is most closely associated with visual processing?
a. frontal
b. temporal
c. parietal
d. occipital

Ans:- D

142. Communication within neurons is_____, communication between neurons is _____.
a. excitatory, inhibitory
b. inhibitory, excitatory
c. chemical, electrical
d. electrical, chemical

Ans:- D

143. Which of the following is NOT a lobe of the brain?
a. frontal
b. dorsal
c. parietal
d. temporal

Ans:- B

A person who is drunk may have difficulty walking in a straight line because the alcohol has impacted their:
a. thalamus
b. reticular formation
c. amygdala
d. cerebellum

Ans:- D

145. Neurotransmitters carry signals across the_____.
a. refractory gap
b. axonal gap
c. synaptic gap
d. hippocampal gap

Ans:- C

146. The poison curare is a(n) _____for the neurotransmitter acetylcholine.
a. antagonist
b. protagonist
c. agonist
d. cure

Ans:- A

147. Damage to the hippocampus is most likely to impair:
a. memory
b. balance
c. sleep
d. breathing
Ans:- A

148. Which part of the limbic system is involved in an animal's feeling of hunger?
a. thalamus
b. pons
c. hippocampus
d. hypothalamus
Ans:- D

149. The_____consists of glands that secrete hormones:
a. nervous system
b. immune system
c. endocrine system
d. cerebral cortex
Ans:- C

150. Testosterone is to_____as estrogen is to_____.
a. thyroid, parathyroid
b. testes, ovaries
c. sympathetic, parasympathetic
d. pancreas, pituitary
Ans:- A

151. What do we call the layer of fatty tissue surrounding the axon of some neurons?
a. cutaneous coating
b. myelin sheath
c. dendritic barrier
d. synaptic sleeve
Ans:- B

152. In the context of brain imaging, what does FMRI stand for?
a. fast moving recovery imaging
b. first moveable recording indicator
c. flexible motion resistance indicator
d. functional magnetic resonance imaging
Ans:- D

153. Which lobe is primarily responsible for hearing and language?
a. temporal
b. parietal
c. frontal
d. occipital
Ans:- A

154. After a car accident, Rhodri had a lot of difficulty planning his day. This is most likely the result of damage to which lobe?
a. temporal
b. parietal
c. frontal
d. occipital
Ans:- C

155. Which area of the brain-stem controls heart rate and breathing?
a. reticular formation
b. medulla
c. pons
d. thalamus
Ans:- B

156. Which structure allows communication between the hemispheres?
a. reticular formation
b. temporal lobe
c. contralateral bridge
d. corpus callosum
Ans:- D

157. Which part of the endocrine system is sometimes called the "master gland"?
a. adrenal gland
b. pancreas
c. pituitary gland
d. pineal gland
Ans:- C

158. Which of the following is NOT part of the endocrine system?
a. pons
b. pancreas
c. parathyroid
d. pineal gland
Ans:- A

159. Where would you see the nodes of Ranvier?
a. on an axon
b. in the cell body
c. on a dendrite
d. a and c
Ans:- A

160. The brain's ability to change in response to experience or damage is called:
a. lateralization
b. lesioning
c. neuroplasticity
d. functionality
Ans:- C

161. Which is the most common neurotransmitter in the brain?

a. serotonin
b. glutamate
c. dopamine
d. GABA

Ans:- B

162. Reductionist and materialist approaches to the study of psychological phenomena led psychology to look for explanations in terms of

a. physiological properties
b. psychological properties
c. evolution
d. social factors

Answer: A

163. Donders (1818–89) introduced psychology to the concept of being able to ascertain the exact duration of a mental judgement following the presentation of a stimulus. This is referred to as

a. mental chronometry
b. zietgerber
c. reaction time
d. mental synchronicity

Answer: A

164. Fechner also proposed the idea that the physical intensity of a physical stimulus is NOT accurately reflected in our perceived intensity of the stimulus. To measure perceived intensity, he proposed the idea of perceptual discrimination – being able to detect changes in the physical intensity itself. The unit of measure was referred to as the

a. Just Negligible Discrepancy
b. Just Noticeable Discrepancy
c. Just Noticeable Difference
d. Just Negligible Difference

Answer: C

165. Francis Galton and Alfred Binet also developed methods for measuring and quantifying

a. personality
b. intelligence
c. locus of control
d. gender

Answer: B

166. An example of a psychological phenomenon that Wundt proposed was beyond experimental or objective scientific methodology is

a. complex feelings
b. drug-–neuron interaction
c. altruistic behaviour

d. adrenal output

Answer: A

167. Wundt also emphasised the importance of researching individuals in their_____and _____contexts in order to fully appreciate psychological phenomena.

a. private, social
b. private, environmental
c. social, cultural
d. social, family

Answer: C

168. Freud's hysteria is now referred to as

a. dissociative disorder
b. personality disorder
c. neuroticism
d. psychoticism

Answer: A

169. What did Freud believe to be the cause of hysteria?

a. neurochemical imbalance
b. faulty cognition
c. unconscious content
d. negative reinforcement

Answer: C

170. Freud was the founder of a form of talking therapy that aims to help the patient to coax unconscious desires into the conscious awareness. This form of therapy is known as

a. behaviourism
b. humanistic therapy
c. transpersonalism
d. psychoanalysis

Answer: D

171. What is the key tenet of Freud's psychoanalytic therapy?

a. all human behaviour is caused by the Oedipus complex
b. all human behaviour is caused by unconscious content
c. all human behaviour is caused by stimulus–response associations
d. all human behaviour is caused by interactions with the environment

Answer: B

172. One of the many means by which Freud analyzed the unconscious content of his patients included

a. interpreting dreams
b. gradual exposure

c. cognitive restructuring
d. interpreting non-verbal behaviour

Answer: A

173. Freud's early ideas regarding the motivation behind human behaviour had important implications for the development of which branch of psychology?

a. therapeutic psychology
b. cognitive psychology
c. atypical psychology
d. abnormal psychology

Answer: D

174. William James's ideas regarding psychological phenomena centred around the idea of

a. a stream of consciousness
b. the sea of the subconscious
c. a stream of subconsciousness
d. a sea of consciousness

Answer: A

175. Two key ideas defined James's concept of a stream of consciousness:
Consciousness has evolved to be _____, in that people choose between alternative courses of action. Consciousness is also_____, in that these choices are important in helping the individual to adapt to his/her environment.

a. selective, functional
b. functional, selective
c. transcendent, predetermined
d. predetermined, transcendent

Answer: A

176. The debate over whether our behaviour and thinking are controlled by physiological, unconscious and environmental forces versus being able to behave and think as we wish, is referred to as

a. the reductionist-determinism debate
b. the freewill-determinism debate
c. the biological-freewill debate
d. the freewill-reductionism debate

Answer: B

177. What was the goal of the behaviourist approach to psychology?

a. to use self-reports of experiences
b. to objectively predict behaviour

c. to condition humans to salivate upon the mere presentation of food
d. to demonstrate the role of freewill in human behaviour via controlled experiments

Answer: B

178. Pavlov's work in demonstrating behaviourist principles regarding the relationship between stimuli and behavioural responses became known as

a. operant conditioning
b. associative learning
c. classical conditioning
d. shaping

Answer: C

179. Thorndike's work demonstrated another form of behaviourist learning, whereby organisms can be trained to display a specific behavioural response more frequently if the outcome of that behaviour led to the acquisition of a desirable reward. This form of conditioned learning is now referred to as

a. operant conditioning
b. classical conditioning
c. positive reinforcement
d. social learning

Answer: A

180. Bartlett, Piaget and Gestalt psychologists like Lewin and Zeigarnik are examples of key figures in psychology who challenged the behaviourist notion that certain processes play no role in determining human behaviour. Which processes are these?

a. biological processes
b. mental processes
c. environmental processes
d. sociocultural processes

Answer: B

181. A key weakness of behaviourist theories is

a. explaining human behaviour based on observations of animal behaviour
b. an overwhelming focus on cognitive processes
c. the use of self-reported data
d. its positive view of all human behaviour

Answer: A

182. Following criticisms of behaviourism, what was the new

approach to exploring psychological phenomena to gain momentum?

a. **cognitive science**
b. **psychoanalysis**
c. **transpersonalism**
d. **phenomenology**

Answer: A

183. Which of the following is an example of an abstract structure that the cognitive approach considers underpins psychological phenomena?

a. **attitudes**
b. **neuronal receptors**
c. **nervous system**
d. **hormones**

Answer: A

184. One of the key methods that cognitive approaches to psychology utilize in order to link subjective mental phenomena to brain function is

a. **implicit association tests**
b. **neurosurgery**
c. **extrasensory perception**
d. **cognitive neuroscience**

Answer: D

185. Humanistic psychologists argue that in order to properly understand human nature, we need to take account of

a. **subjective human experience**
b. **underlying mental disturbances**
c. **inherent gender differences**
d. **repressed animal instincts**

Answer: A

186. Key figures in psychology who propelled humanism include

a. **Laurel and Hardy**
b. **Maslow and Rogers**
c. **Pegg and Frost**
d. **Watson and Skinner**

Answer: B

187. Which of the following does Rogers NOT list as a feature of a psychologically healthy person?

a. **spontaneity and flexibility**
b. **creativity**
c. **a firm belief in his/her own importance**
d. **the will to follow his/her own instincts**

Answer: C

188. The concept that modern psychologists will usually use techniques that best fit the problem they're investigating is referred to as

a. expedient psychology
b. the path of least resistance
c. pragmatic psychology
d. the limited horizon hypothesis

Answer: C

189. Frederic Bartlett carried out an investigation that demonstrated how the accuracy of a person's recall of details from a story could be significantly distorted by

a. whether or not someone has eaten in the last hour
b. the temperature of the room where the experiment was conducted
c. the cultural background of the person hearing the story
d. the current phase of the moon

Answer: C

190. What research method has been associated with psychology's return to a focus on the importance of subjective psychological phenomena?

a. qualitative
b. self-reports
c. face-to-face interviews
d. psychometrics

Answer: A

191. The most important historical figure to develop the idea of evolution is

a. Darwin
b. Mendel
c. Crick
d. Buss

Answer: A

192. System of the body which coordinates and controls its activity is known as _____

a) Organ system
b) Muscular system
c) Nervous tissue
d) Nervous system

Answer: d

Explanation: Nervous system is the one which is responsible for all the activities of the body. It coordinates and controls the activities of the animal.

193. Peripheral nervous system consists of the brain and spinal cord.

a) True
b) False

Answer: b

Explanation: Nervous system has two subdivisions, i.e., CNS and PNS. CNS or central nervous system consists of the brain and spinal cord

while PNS or peripheral nervous system includes all nervous tissues outside the CNS.

194. Which of the following is NOT the component of the PNS?
a) Elastic connective tissue
b) Cranial nerves
c) Spinal nerves
d) Ganglia
Answer: a
Explanation: Peripheral nervous tissue consists of all nervous tissue outside the central nervous system. The main components of PNS are spinal nerves and their branches, cranial nerves and their branches, sensory receptors, and ganglia.

195. Name the basic structural and functional unit of the nervous system.
a) Neuroglia
b) Glial cells
c) Neurons
d) Perikaryon
Answer: c
Explanation: Nervous system has been composed of two types of cells, i.e., neurons and neuroglia. Neurons are the basic functional and structural unit of the nervous system.

196. Which of the following cells supports, nourishes, and protect the neurons?
a) Nissl bodies
b) Perikaryon
c) Ganglia
d) Glial cells
Answer: d
Explanation: Glial cells (glia = glue)are also called neuroglia, these cells support, nourishes, and protect the neurons while ganglia are the cluster of cell bodies which found in the PNS.

197. What is the speed of nerve impulse?
a) 60 m/s
b) 0.5 – 130 m/s
c) 10-30 m/s
d) 50 -150 m/s
Answer: b
Explanation: Nerve impulse or action potential is the electrical signals which travel through the membrane of the neurons. The speed of these signals ranges from 0.5 to 130 m/s.

198. What are Nissl bodies?
a) Golgi bodies
b) Lysosomes
c) Cluster of rough endoplasmic reticulum
d) Mitochondria
Answer: c
Explanation: Neurons are made up of three parts, i.e., cell body, dendrites, and axon. The cell body consists of ribosomes and a cluster of endoplasmic reticulum, which is known as Nissl bodies.

199. Which of the following is NOT found in axon?
a) Endoplasmic reticulum
b) Neurofibrils
c) Mitochondria
d) Microtubules
Answer: a
Explanation: Endoplasmic reticulum is not present in axons as it does not synthesize protein. An axon contains mitochondria, neurofibril, and microtubule and the cytoplasm of an axon is called axoplasm.

200. Name the multipolar neuron which is located entirely within the central nervous system.
a) Motor neuron
b) Efferent neuron
c) Afferent neuron
d) Interneuron
Answer: d
Explanation: Interneurons are the multipolar neurons, which are found within the CNS. Motor neurons are also known as efferent neurons, they transfer signals from the CNS to effector organs.

201. Out of the following, which one does not affect the speed of conduction of nerve impulse.
a) No. of ganglia
b) Myelin sheath
c) Axon diameter
d) Temperature
Answer: a
Explanation: The speed of conduction of nerve impulse depends upon three factors, i.e., myelin sheath, temperature, and axon diameter. Higher the temperature higher would be the speed and also larger the diameter higher the speed.

202. The eyes are the most complex sense organ of the body.
a) True
b) False

Answer: a
Explanation: There are number of receptors in the eye, the lens concentrates light on these receptors which thusly made a motivation. This drive goes to the cerebrum and produces pictures.

203. Which of the following is known as the "window of the brain"?
a) Sensory organs
b) Cranial nerves
c) Eyes
d) Ganglia
Answer: a
Explanation: Sensory organs are considered as the "window of the brain". When external stimuli contacted with sensory receptors, it sends signals to the brain in the form of nerve impulse which results in the sensation.

204. Which of the following helps in maintaining the shape of the eye?
a) Neuroglia
b) Aqueous humor
c) Vitreous humor
d) Perikaryon
Answer: c
Explanation: Vitreous humor is a viscous mass that helps in maintaining the shape of the eye. The lens is surrounded by the aqueous humor from one side and vitreous humor from the other side.

205. Mark the INCORRECT statement about the lens?
a) Protein found in the lens are α, β, and γ crystalline
b) Composed of water and proteins
c) Mainly made up of water
d) It has a blood supply
Answer: d
Explanation: Though lens does not have a blood supply, it is active. Lens is basically made up of water and protein and many vertebrates have lens protein α, β, and γ crystalline.

206. What is Sclera?
a) Cornea
b) White part of the eye
c) Red part of the eye
d) Lens
Answer: b
Explanation: Sclera is the white part of the eye which covers the entire eye except for cornea and is made up of collagen fibers and fibroblast.

207. Name the part of the eye, which is involved in focusing light on the

retina?
a) Sclera
b) Iris
c) Cornea
d) Ciliary muscles
Answer: c
Explanation: Fibrous tunic is composed of anterior cornea and posterior sclera. It is a surface coating of an eyeball. Transparent cornea covered colored iris and it helps in focussing light on the retina.

208. Iris is found in which layer of the eyeball?
a) Vascular tunic
b) Retina
c) Fibrous tunic
d) Microtubules
Answer: a
Explanation: Eyeball is made up of three layers, i.e., fibrous tunic, vascular tunic, and retina. The middle layer of the eyeball is a vascular tunic. It consists of three parts: ciliary body, iris, and choroid.

209. Among the following, which is one is more vascularized and pigmented.
a) Cornea
b) Iris
c) Ciliary body
d) Choroid
Answer: d
Explanation: Choroid is highly pigmented with melanin and vascularized structure which forms the posterior region of vascular tunic. It absorbs scattered light and also supplies blood.

210. Name the part of the eye which produces aqueous fluid that fills the front part of the eye.
a) Ciliary body
b) Cornea
c) Vitreous humor
d) Uvea
Answer: a
Explanation: In the back locale of vascular tunic choroid end up a ciliary body. Ciliary body produces the watery liquid that fills the front piece of the eye and it is likewise situated behind the iris.

211. In human ear, secretion of wax is done by_____
a) Cochlea
b) Vestibule
c) Basilar membrane
d) Ceruminous glands
Answer: d

Explanation: Human ear has the number of sweat glands called ceruminous glands. These glands are present on the skin from exterior to interior part. The secretion of these glands called cerumen or wax.

212. Human ear converts sound energy to mechanical energy which is transmitted to the brain through nerve impulse.
a) True
b) False
Answer: a
Explanation: The human ear works as a transducer which converts sound energy into mechanical energy to a nerve impulse which further detected by the brain.

213. Conversion of vibrations into compressed wave takes place in which part of human ear?
a) Inner ear
b) Middle ear
c) Outer ear
d) Exterior ear
Answer: a
Explanation: Ear is broadly divided into three parts that are outer, middle, and inner. Sound wave goes through the outer ear gets converted to vibration by middle ear. Passing of vibration to inner ear further converts it in the form of compresses wave.

214. Name the light absorbing pigment present in the Rods?
a) Neuroglia
b) Aqueous humor
c) Rhodopsin
d) Perikaryon
View Answer
Answer: c
Explanation: The light absorbing pigment present in the rods is rhodopsin and it is also a G-protein coupled receptor which upon activation activates transducin.

215. Name the G- protein, which takes part in vision?
a) Ethylene
b) Adenosine
c) Acetylcholine
d) Transducin
Answer: d
Explanation: Rhodopsin activates molecules of transducin which further activates an enzyme to break down cyclic GMP. The drop in cyclic GMP will open sodium channel which is responsible for vision.

216. What is the absorption peak of green absorbing cones?
a) 565 nm
b) 535 nm
c) 768 nm
d) 440 nm
Answer: b
Explanation: The color vision of our eye is dependent on the three types of cones, i.e., green absorbing, red absorbing cones, and blue absorbing cones.

217. Which of the following is NOT true for Rods?
a) Used for scotopic vision
b) Loss causes night blindness
c) Not very light sensitive
d) Confer achromatic vision
Answer: c
Explanation: Rods are very light sensitive while cons are not that much light sensitive. Cons enable us to see colors by producing sharpest images.

218. Name the tiny bone of the middle ear, which convert sound into vibration?
a) Stapes
b) Malleus
c) Incus
d) Anvil
Answer: a
Explanation: The space of the middle ear is filled with air where the tympanic membrane separates the inner and external ear. Eardrum transfer sound energy to middle ear, which in turn convert it to vibrate.

219. Organs involve in the sensation of the body is known as _____
a) Organ system
b) Muscular system
c) Nervous tissue
d) Sensory organs
Answer: d
Explanation: Those organs which include hearing, seeing, taste and smell are known as sensory organs. For ex: eye, ear, nose, skin, and tongue.

220. Name the hormone which takes part in the release of FSH and LH from the anterior pituitary.
a) Growth hormone
b) GnRH
c) Somatostatin
d) TRH
Answer: b
Explanation: GnRH is Gonadotropin

Releasing Hormone, which is responsible for the release of follicle stimulating hormone (FSH), and luteinizing hormone (LH).

221. Chemical messengers secreted by ductless glands are called_____
a) Lymph
b) Platelets
c) Plasma
d) Hormones
Answer: d
Explanation: Hormones are the chemical messengers which are secreted by the ductless glands called endocrine glands. These glands are controlled by the endocrine system.

222. Endocrine glands secret products into the ducts and transfer it into body cavities.
a) True
b) False
Answer: b
Explanation: Endocrine glands are called ductless glands. They secrete their products directly into the bloodstreams and circulate in the body.

223. Which of the following is NOT an endocrine gland?
a) Hypothalamus
b) Pituitary
c) Parathyroid
d) Pancreas
Answer: a
Explanation: All of them are endocrine glands except hypothalamus. Hypothalamus and thymus are not classified as an endocrine gland, but included in the endocrine system as they involve in the secretion of hormones.

224. Which of this statement is INCORRECT regarding the function of hormones?
a) Reproduction and sexual differentiation
b) Maintenance of internal environment
c) Maintain body temperature
d) Development and growth
Answer: c
Explanation: Hormones are released by specialized cells of the endocrine glands and act on distantly located target cells. A single hormone can contribute many functions and sometimes many hormones can perform a single function.

225. Mark the one, which is NOT the precursor of the hormone?
a) Amino acids
b) Cholesterol
c) Phospholipids
d) Proteins
Answer: d
Explanation: Chemically, hormone can be divided into two categories, i.e., lipid soluble and water soluble hormones.

226. What is the precursor of steroid hormone?
a) Protein
b) Cholesterol
c) Carbohydrate
d) Lipid
Answer: b
Explanation: Cholesterol acts as a precursor of steroid hormone. DHEA is a natural steroid hormone which is synthesized from cholesterol.

227. Which of the is a fat soluble hormone?
a) Amine hormone
b) Peptide hormone
c) Thyroid hormone
d) Protein hormone
Answer: c
Explanation: Thyroid is a lipid soluble hormone while amine, peptide, and protein hormones are water soluble, ranging from size 3 to over 200 amino acids.

228. Name the hormone which is synthesized from histidine amino acid?
a) Histamine
b) Epinephrine
c) Norepinephrine
d) Dopamine
Answer: a
Explanation: Epinephrine, norepinephrine, and dopamine are amine hormones, which are synthesized by modifying amino acid tyrosine.

229. Which of the following is protein hormone?
a) Oxytocin
b) Insulin
c) TSH
d) Antidiuretic hormone
Answer: b
Explanation: Insulin and human growth hormones are protein hormone while oxytocin and antidiuretic hormones are peptide hormones. TSH or thyroid

stimulating hormone has carbohydrate attached to the protein so it comes under glycoprotein hormone.

230. Name the gland, which releases Neurohormone.
a) Hypothalamus
b) Pituitary
c) Thyroid
d) Pancreas
Answer: a
Explanation: Neurohormone are those which changes their function according to their requirements like they can be releasing hormones or inhibiting hormone.

231. Name the process of gaseous exchange in the body.
a) Lymphatic system
b) Respiration
c) Cardiovascular system
d) Respiratory system
Answer: b
Explanation: Respiration is the process of gaseous exchange in the body while cardiovascular regulates the blood flow throughout the body.

232. Nose, larynx, pharynx, lungs, trachea, and bronchi are the parts of the respiratory system.
a) True
b) False
Answer: a
Explanation: Respiratory system consists of all the organs which take part in the respiration. It includes bronchi, trachea, lungs, nose, larynx, and pharynx.

233. Which of the following is NOT the function of the respiratory system?
a) Regulate blood pH
b) Helps in gaseous exchange
c) Protection against blood loss
d) Contains receptors for the sense of smell
Answer: c
Explanation: Respiratory system helps in regulation of blood, pH, and also contain receptors of smell, produces vocal sound and filter inspired air while cardiovascular system protects against blood loss by the formation of blood clots.

234. Which of this statement is TRUE for pulmonary respiration?
a) Exchange of gases between alveoli of lungs and the blood
b) Exchange of gases between blood

and tissue cells
c) Breathing between the atmosphere and the alveoli of the lungs
d) Production of ATP
Answer: a
Explanation: Pulmonary respiration is the exchange of gases between the alveoli of the lungs and the blood in the capillaries. Exchange of gases between blood and tissue cell occurs in internal respiration.

235. Which of the following controls the normal breathing process?
a) Amino acids
b) Cholesterol
c) Ventral respiratory group
d) Dorsal respiratory group
Answer: d
Explanation: Ventral respiratory group contains both inspiratory and expiratory neurons and controlled forced breathing while dorsal respiratory group contains only inspiratory neurons control normal breathing.

236. Oxygen and hemoglobin bind in a reversible manner to form_____
a) Carboxyhemoglobin
b) Oxyhemoglobin
c) Methoglobin
d) BPG
Answer: b
Explanation: Oxyhemoglobin is formed by the combination of oxygen and hemoglobin. Oxygen binds to the hemoglobin in a reversible manner. 98% of oxygen is trapped inside RBC.

237. How many oxygen molecules bound to hemoglobin to give 50% saturation?
a) 6
b) 4
c) 2
d) 7
Answer: c
Explanation: Hemoglobin can bind with maximum 4 oxygen molecules, so for obtaining 50% saturation only 2 molecules of oxygen should be bound to hemoglobin.

238. What is the name of the gland which secrete melatonin?
a) Pituitary gland
b) Pineal gland
c) Thyroid gland
d) Hypothalamus
Answer: b
Explanation: Pineal gland is the

smallest endocrine gland attached to the roof of the brain and secrete melatonin. Melatonin is responsible for settling of the biological clock.

239. Which of the following is Growth hormone inhibiting hormone?
a) FSH
b) TRH
c) GHRH
d) Somatostatin
Answer: d
Explanation: Somatostatin works against the growth hormone (GHRH), so it is known as growth inhibiting hormone. It consists of two peptides of 14 and 28 amino acids and is released from neurosecretory nerves.

240. Mark the one, which is not inhibited by the effect of somatostatin.
a) GH
b) TSH
c) Glucagon
d) Dopamine
Answer: d
Explanation: Dopamine is prolactin inhibiting hormone (PIH), which inhibit the release of prolactin from the anterior pituitary. It also functions as a neurotransmitter.

241. Gibson's direct theory of perception is important because it shows perception to be
a. top–down
b. constructive
c. impoverished
d. dynamic
Answer: D

242. Before light is absorbed by cells in the retina, it travels through a number of structures at the front of the eye. What is the correct order of these structures?
a. cornea; pupil; lens
b. pupil; cornea; lens
c. cornea; lens; pupil
d. pupil; lens; cornea
Answer: A

243. What transmits electrical information from the ear to the brain?
a. outer hair cells
b. auditory nerve fibres
c. ganglion cells
d. rods and cones
Answer: B

244. How many chambers are there in the human cochlea?

a. 1
b. 2
c. 3
d. 4

Answer: C

245. Perception is …

a. … an accurate representation of the world
b. … an appropriate representation of the world
c. … an adequate representation of the world
d. … a native representation of the world

Answer: C

246. A driver fails to notice a pedestrian who has just stepped out into the road. This is an example of

a. change blindness
b. attentional blindness
c. space-based attention
d. inattentional blindness

Answer: D

247. In the cochlea, the basal membrane is tonotopic, i.e. sounds are

a. organized spatially according to frequency
b. organized in terms of how frequently they fire
c. organized spatially according to the size of connecting nerve fibres
d. organized according to left or right ear input

Answer: A

248. Which one of the following is NOT a pair of Gestalt psychology principles?

a. continuity and closure principles
b. similarity and emergence principles
c. symmetry and order principles
d. proximate and eminence principles

Answer: D

249. The organ of Corti is responsible for

a. limiting sound amplitude so as not to damage the inner ear organs
b. reducing the amount of environmental noise
c. amplifying attended sounds

d. converting basilar membrane movement to brain activity

Answer: D

250. Name the hormone, which is released by the posterior pituitary.

a) Oxytocin

b) TSH

c) ICSH

d) Prolactin

Answer: a

Explanation: Oxytocin and vasopressin are released by the posterior pituitary. Posterior pituitary does not synthesize hormones, but it can store and release these two hormones.

251. Which area of the temporal lobes is thought to be specialized for processing face-like stimuli?

a. the fusiform gyrus area (FGA)
b. the focal face area (FFA)
c. the fusiform facial area (FFA)
d. the face formation arena (FFA)

Answer: C

252. Which one of the following statements is NOT an account of constructivist perception?

a. perception is not just sensation, it is an active process
b. perception is a direct by-product of sensations and hypotheses about the world and how it works
c. perception is derived from visual information in the optic array
d. perception is influenced by individual differences

Answer: C

253. The auditory ventral stream terminates in

a. Shatner's bassoon
b. orbitofrontal cortex
c. dorsolateral prefrontal cortex
d. cingulate gyrus

Answer: B

254. Rod photoreceptors are principally involved in processing

a. colour
b. movement
c. visual acuity
d. location

Answer: B

255. Cells leaving the eye travel along two major visual routes (and

some minor ones). One of these is the lateral genicular pathway. What is the other major pathway?

a. **The ocular geniculate pathway**
b. **The tuberoinfundibular pathway**
c. **The mesocortical pathway**
d. **The retinotectal pathway**

Answer: D

256. In the direct theory of perception, information in the visual field that remains constant is the

a. **optic array**
b. **optic flow**
c. **invariant**
d. **affordance**

Answer: C

257. Two processes that when independently disrupted leave the other one intact are known as

a. **double jeopardy**
b. **double entendre**
c. **double dissociation**
d. **double association**

Answer: C

258. What is the name for the phenomenon of experiencing one kind of impression when stimulated by a different sensory organ stimulus (e.g. tasting shapes, smelling colour, seeing sounds)?

a. **divided attention**
b. **synaesthesia**
c. **prosopagnosia**
d. **perceptual load**

Answer: B

259. The fovea contains a concentration of

a. **cones**
b. **rods**
c. **rods and cones**
d. **vitreous humour**

Answer: A

260. Which of the following is NOT an element of Broadbent's theory of attention?

a. **limited capacity processor**
b. **selective filter**
c. **sensory buffer**
d. **spotlight**

Answer: D

261. The direct perception of an object's purpose is the

a. **ecological optic**
b. **affordance**
c. **invariant**
d. **optic array**

Answer: B

262. Glass micro-capillaries are a type of micro electrode.
a) True
b) False
Answer: a
Explanation: Two types of micro electrodes are generally used: metallic and glass microcapillaries. Metallic electrodes are formed from a fine needle of suitable metal drawn for a fine tip. Glass electrodes are drawn from Pyrex glass of special grade.

263. Glass microcapillaries are preferred over metallic electrodes because of the former _____
a) polarizes with input current
b) does not have sustainable current carrying capacity
c) has less contact surface area
d) has sustainable current carrying capacity
Answer: d
Explanation: Metallic electrodes polarize with smaller amplifier input currents. Hence, they tend to develop unstable electrode offset potential and are therefore not preferred for steady state potential measurement. On the other hand, in case of glass micro electrodes have a sustainable current carrying capacity because of the large surface area between the metal and the electrolyte.

264. Do metallic micro electrodes exist.
a) True
b) False
Answer: a
Explanation: Two types of micro electrodes are generally used: metallic and glass microcapillaries. Metallic electrodes are formed from a fine needle of suitable metal drawn for a fine tip. Glass electrodes are drawn from Pyrex glass of special grade.

265. Metallic micro electrodes have impedance_____compared to conventional electrodes?
a) equal
b) smaller
c) high
d) very high
Answer: d
Explanation: The very high impedance of the metal micro-electrodes is due to the characteristics of the small area

metal-electrolyte interface. Because of very high impedance of micro electrodes, amplifiers with extremely high input impedance are required to avoid loading the circuit and to minimize the effects of small change in interface impedance.

266. Which of the following electrode is manufactured by circumferential application of heat to a small area of glass tubing and pulling the glass when it gets soft?
a) macro metallic electrodes
b) micro metallic electrodes
c) micro pipette
d) surface electrodes
Answer: c
Explanation: The most commonly used method for making small tip micropipette consists of the circumferential application of heat to a small area of glass tubing which is placed under some initial tension. When the glass softens, the tension is increased very rapidly and the heat is turned off. Proper timing, controlled adjustment of the amount of heat as well as the initial and final tensions and cooling results in the production of microcapillaries with control dimensions.

267. Which of the following metal is preferred for manufacturing micro electrodes?
a) Stainless steel
b) Tungsten
c) Iron
d) Copper
Answer: b
Explanation: Tungsten is preferred for constructing micro-electrodes due to its mechanical strength and its apparent inertness. Although tungsten itself is reactive, a surface layer of tungsten oxide will, in most situations, protect the metal against corrosion.

268. _____are devices which convert one form of energy into another.
a) transducers
b) electrodes
c) impulses
d) opamp
Answer: a
Explanation: Transducers are devices which convert one form of energy into another. A number of factors decide the choice of a particular transducer to be used for the study of a specific phenomenon. Many

physical, chemical and optical properties and principles can be applied to construct transducers for applications in the medical field.

269. Which type of electrodes are employed to study the electrical activities of individual cells?
a) milli-electrodes
b) micro-electrodes
c) surface-electrodes
d) pre-jelled electrodes
Answer: b
Explanation: To study the electrical activities of individual cells, micro electrodes are employed. This type of electrode is small enough with respect to the size of the cells. Typical micro electrodes have tip dimensions ranging from 0.5-5 microns.

270. Pulse oximetry is used to measure the oxygen level in blood & heart rate.
a) True
b) False
Answer: a
Explanation: Pulse oximetry is a technology used to measure the oxygen level in your blood and your heart rate. A finger pulse oximeter is equipped with technology to rapidly detect changes in your blood oxygen level.

271. Sudden involuntary drop in body core temperature below 35*C (95*F) is called _____
a) Accidental hyperthermia
b) Accidental misothermia
c) Accidental exothermia
d) Accidental hypothermia
Answer: d
Explanation: Sudden involuntary drop in body core temperature below 35*C (95*F) is called Accidental hypothermia. In this, the body temperature drops very quickly. If not treated on time can lead to patients death.

272. Which of the following has the widest range of temperature measurement?
a) RTD
b) Thermocouple
c) Thermistor
d) Mercury thermometer
Answer: b
Explanation: Thermocouple has the widest range of temperature measurement from -184^{0}C to +2300^{0}C. RTD has a range of -200^{0}C

to +850^{0}C. Thermistor has a range of 0^{0}C to 100^{0}C where as conventional mercury thermometers range is -37^{0}C to +356^{0}C.

273. The junction at a higher temperature in thermocouple is termed as measuring junction.
a) True
b) False
Answer: a
Explanation: The junction at a higher temperature in thermocouple is termed as measuring junction. The junction at lower temperature in the thermocouple is called the reference temperature. The cold junction is usually kept at 0^{0}C.

274. When two wires of different material are joined together at either end, forming two junctions which are maintained at a different temperature, a thermo-motive force is generated causing a current to flow around the circuit. This arrangement is called _____
a) thermal pair
b) thermistor
c) thermocouple
d) thermostat
Answer: c
Explanation: This arrangement is called thermocouple. The junction at a higher temperature in thermocouple is termed as measuring junction. The junction at lower temperature in the thermocouple is called the reference temperature.

275. When two wires of different material are joined together at either end, forming two junctions which are maintained at a different temperature, a_____force is generated.
a) thermo-motive
b) electro-motive
c) chemical reactive
d) mechanical
Answer: a
Explanation: When two wires of different material are joined together at either end, forming two junctions which are maintained at a different temperature, a thermo-motive force is generated causing a current to flow around the circuit. This arrangement is called thermocouple. The junction at higher temperature in thermocouple is termed as measuring junction. The junction at lower temperature in the

thermocouple is called the reference temperature.

276. The junction at a lower temperature in the thermocouple called measuring junction.
a) True
b) False
Answer: b
Explanation: The junction at a lower temperature in the thermocouple is called the reference temperature. The cold junction is usually kept at 0^0C. The junction at a higher temperature in thermocouple is termed as measuring junction.

277. The lower temperature junction in thermocouple is maintained at _____
a) -273 K
b) 0 K
c) -327 K
d) 273 K
Answer: d
Explanation: The lower temperature junction in thermocouple is maintained at 273 K (0^0C). The junction at lower temperature in the thermocouple is called the reference temperature. The junction at higher temperature in thermocouple is termed as measuring junction.

278. The resistance Rt of a metallic conductor at any temperature t is given by _____
a) Rt = Ro(1+αt)
b) Rt = Ro(1-αt)
c) Rt = Ro(αt-1)
d) Rt = Ro(10+αt)
Answer: a
Explanation: The resistance Rt of a metallic conductor at any temperature t is given by Rt = Ro(1+αt). Ro is the resistance at 0*C. α is temperature coefficient of resistivity.

279. RTD stands for _____
a) resistance temperature device
b) resistance temperature detector
c) reluctance thermal device
d) resistive thermal detector
Answer: b
Explanation: RTD stands for Resistance Temperature Device. It is a passive sensor and requires current excitation to produce an output voltage. RTD has very low temperature coefficient. Voltage drop across RTD is much larger than thermocouple output voltage.

280. Thermister is used to measure _____

a) temperature
b) pressure
c) height
d) displacement
Answer: a
Explanation: Thermistor is used to measure temperature. It is a temperature transducer. With a change in temperature its resistance changes. Thus its working principle is variable resistance. Thermistors are the oxides of certain metals like manganese, cobalt and nickel which have large negative temperature coefficient, i.e. resistance decreases with increase in temperature.

281. Doppler velocimetry works on the principle of _____

a) frequency measurement of fiber optic sensor
b) amplitude measurement of fiber optic sensor
c) phase measurement of fiber optic sensor
d) time shift measurement of fiber optic sensor
Answer: a
Explanation: Doppler velocimetry works on the principle of frequency measurement of fiber optic sensor. In this method, light from a laser, normally helium/neon, is sent via a fibre onto the skin surface. The moving red blood cells scatter the light and produce a Doppler frequency shift because of their movement.

282. Fluoroptic temperature sensors work on the principle of _____

a) thermistor
b) thermocouple
c) optical fiber
d) rtd
Answer: c
Explanation: Fluoroptic temperature sensors work on the principle of optical fiber sensors. They contain a rare earth phosphor which is illuminated by a white light along a short length of large core optical fibre. The light excites the phosphor which emits a number of lines. By using filters, two of these lines at 540 and 630 nm are selected, and the ratio of their intensities is a single valued function of the temperature of the phosphor.

283. Monopolar needle electrode have a coating of which material over the stainless steel wires which are bare only at the tips?
a) carbon
b) calcium
c) sodium
d) teflon
Answer: d
Explanation: The monopolar needle electrode consists of a teflon coated stainless steel wire. The wire is bare only at the tip. It is found that after the needle has been used a number of times, the teflon coating will recede, increasing the tip area. The needle should be discarded when this happens.

284. Endoscopic imaging uses _____
a) thermal sensors
b) chemical sensors
c) optic fiber sensors
d) pressure sensors
Answer: c
Explanation: Optic sensors are used for endoscopic imaging. Optical fibre sensors are non-electrical and hence are free from electrical interference usually associated with electronically based sensors. They are suitable for telemetry applications as the bulk of the instrumentation can be at a reasonable distance from the patient.

285. _____converts biochemical events into measurable signals.
a) amplifier
b) opamp
c) rectifier
d) transducer
Answer: d
Explanation: Transducers convert biochemical events into measurable signals. They provide the means for detecting the biochemical changes inside the body. Particularly biosensors are employed for this purpose.

286. The biological response of the biosensor is determined by _____
a) biocatalytic membrane
b) physio-chemical membrane
c) chemical membrane
d) artificial membrane
Answer: a
Explanation: The biological response of the biosensor is determined by biocatalytic membrane. The biocatalytic membrane accomplishes

the conversion of reactant to product. The product of the reaction diffuses to the transducer. This then causes the electrical response.

287. Home blood glucose sensor works on which principle?
a) electro-physiological
b) electrochemical
c) physio-chemical
d) chemical
Answer: b
Explanation: Home blood glucose detection sensor works on the principle of electrochemical. The biosensor in this instrument relies upon enzymes that recognise and catalyze reactions of glucose with the generation of redox – active species that are detected electrochemically.

288. The chemical reaction of glucose with oxygen is catalyzed in the presence of _____
a) glucose oxidase
b) monoglucose carbodase
c) glusoce dioxidase
d) biglucose oxidase
Answer: a
Explanation: The chemical reaction of glucose with oxygen is catalyzed in the presence of glucose oxidase. In the presence of glucose oxidase as a catalyst, the glucose and oxygen react and gluconic acid is produced as by product. Hydrogen perioxide (H_2O_2) is also produced in some amount.

289. Home blood glucose measurement devices measure the glucose level through non-invasive method.
a) True
b) False
Answer: b
Explanation: Home blood glucose measurement devices measure the glucose level through invasive method. There is a small needle at the tip of the machine that pierces the skin to take blood sample. This blood is then undergoes electrochemical reactions and the glucose level is determined.

290. Blood glucose level measurement device uses a biosensor works on the principle of electrochemical.
a) True
b) False
Answer: a

Explanation: Home blood glucose detection sensor works on the principle of electrochemical. The biosensor in this instrument relies upon enzymes that recognize and catalyze reactions of glucose with the generation of redox – active species that are detected electrochemically.

291. Which of the following is not a fundamental block in recording systems?
a) electrodes and transducers
b) signal conditioner
c) analysis for the output
d) writing system
Answer: c
Explanation: Analysis of the output is not a fundamental block on the recording system. First, the signals are collected from the host. Then they are sent for signal conditioning where they are amplified to the desirable range and then the writing system prints the signals.

292. In medical recorders, the signal of interest is of the order of _____
a) nanovolts
b) microvolts
c) megavolts
d) volts
Answer: b
Explanation: The signals of interest in medical recorders are in the range of micro volts. They are captured by the help of sensitive electrodes and transducers and then amplified to a certain higher level. After the amplification further processing is carried out.

293. In medical devices, the amplifiers that are used for the amplification purpose of the input signal must have _____
a) low frequency response
b) high frequency response
c) average frequency response
d) frequency response has no role to play in it
Answer: a
Explanation: The bioelectric signals in medical science contains components of extremely low frequency. Thus the amplifiers must also have a low frequency response. The response should be down to less than one hertz which is a very frequent requirement.

294. To achieve the low frequency response for medical applications,

the amplifier configuration must contain?
a) higher resistance
b) higher capacitance
c) lower resistance
d) lower capacitance
Answer: b
Explanation: To achieve the low frequency response required for medical applications, the amplifier must have large values of coupling capacitance. In all RC-coupled amplifiers, low frequency response is limited by the reluctance of the coupling capacitors. The response should be down to less than one hertz which is a very frequent requirement.

295. Filter that amplifies frequency above a certain value is called?
a) low pass filter
b) high pass filter
c) band pass filter
d) band stop filter
Answer: b
Explanation: High pass filter amplifies signal above a certain frequency. Low pass filter amplifies signals below a certain frequency. Band pass filter amplifies frequencies within a certain band. Band stop filter amplifies all the frequencies except those in a certain band.

296. _____amplifies all the frequencies except those in a certain band.
a) high pass filter
b) low pass filter
c) band pass filter
d) band stop filter
Answer: d
Explanation: Band stop filter amplifies all the frequencies except those in a certain band. High pass filter amplifies signal above a certain frequency. Low pass filter amplifies signals below a certain frequency. Band pass filter amplifies frequencies within a certain band.

297. Active filters use opamps in addition to passive components in order to obtain better performance.
a) True
b) False
Answer: a
Explanation: True. Active filters use opamps in addition to passive components in order to obtain better performance. Operational amplifiers are frequently used as the

gain blocks in active filters. Passive components are resistors capacitors and inductors.

298. Which of the following component is not a part of the passive filter?
a) resistor
b) operational amplifier
c) capacitor
d) inductor
Answer: b
Explanation: Operational amplifier is not a part of passive filters. It is a part of an active filter. Passive components are resistors capacitors and inductors. Active filters use opamps in addition to passive components in order to obtain better performance.

299. Light passing through finger will be adsorbed by _____
(i) Skin Pigments
(ii) Tissue
(iii) Arteries
(iv) Veins
a) (i) & (iii)
b) (ii) & (iv)
c) (i) & (ii)
d) (iii) & (iv)
Answer: c
Explanation: The two wavelengths assume that only two absorbers are present; namely oxyhaemoglobin (HbO2) and reduced haemoglobin (Hb).Light passing through the ear or finger will be absorbed by skin pigments, tissue, cartilage, bone, arterial blood, venous blood.

300. How is the blood flow in arteries and arterioles?
a) plug
b) laminar
c) parabolic
d) pulsatile
Answer: d
Explanation: Most of the absorbances are fixed and do not change with time. Even blood in the capillaries and veins under steady state metabolic circumstances is constant in composition and flow, at least over short periods of time.Only the blood flow in the arteries and arterioles is pulsatile.

301. The manufacture of adrenalin and noradrenalin is controlled by:
(a) Nervous system
(b) Endocrine system
(c) Regulatory system
(d) Circulatory system

(e) Homeostasis
Answer: A

302. Repression is a common mode of resolving:
(a) Anxieties
(b) Tensions
(c) Conflicts
(d) Motives
(e) None of these
Answer: C

303. The defense mechanisms are reactions to:
(a) Frustration
(b) Psychosexual behaviour
(c) Aggression
(d) Goaldirected behaviour
(e) None of these
Answer: A

304. Dynamic psychology is the psychology of:
(a) Motivation and Emotion
(b) Perception and Attention
(c) Learning and Memory
(d) Personality and Intelligence
(e) None of these
Answer: A

305. Both the terms "emotion" and "motivation" came from the same Latin root:
(a) Movement
(b) Move
(c) Moment
(d) "Movere"
(e) None of these
Answer: D

306. According to Lewin, tensions are emotional states which accompany:
(a) Needs
(b) Motives
(c) Goals
(d) Anxieties
(e) None of these
Answer: A

307. In avoidance-avoidance conflict, the individual is compelled to choose between:
(a) One positive and one negative alternative
(b) Two negative alternatives
(c) Two positive alternatives
(d) Two negative alternatives and two positive alternatives
(e) None of the above
Answer: B

308. A releaser is a highly specific stimulus that "triggers" or initiates:
(a) Response
(b) Social Behaviour
(c) Gregariousness
(d) Species-specific behaviour
(e) None of the above
Answer: D

309. Who assumed that human motives are arranged in a hierarchy of potency?
(a) Neal Miller (1959)
(b) Janis& Mann (1977)
(c) Jerome Singer (1962)
(d) A. H. Maslow (1970)
(e) Schachter (1967)
Answer: D

310. Corpus luteum and placenta of pregnant women secret the hormone:
(a) Estrogens
(b) Androgens
(c) Progestins
(d) Adrenalin
(e) None of the above
Answer: C

311. According to Maslow, the self-actualizing tendency is:
(a) Instinct
(b) Imprinting
(c) Growth Motivation
(d) Deficiency motivation
(e) None of the above
Answer: C

312. Need for achievement can be measured by:
(a) Binnet's scale
(b) Thurstone's scale
(c) TAT (Thematic Apperception Test)
(d) Semantic Differential scale
(e) None of the above
Answer: C

313. The desire to be with one's own kind is termed as:
(a) Gregariousness
(b) Consumatory behaviour
(c) Imprinting
(d) Coolidge Effect
(e) None of the above
Answer: A

314. The type of conflict in which the goal of the individual has both positive and negative valence of approximate equal intensity is known as:
(a) Approach-avoidance conflicts
(b) Avoidance-avoidance confects
(c) Approach-approach conflict

(d) Multiple approach-avoidance conflicts
(e) None of the above
Answer: A

315. A young woman who turns herself into a religious worker has a strong:
(a) Approach gradient
(b) Social Motive
(c) Hypervigilance
(d) Encephalization
(e) None of the above
Answer: B

316. The author of the hierarchical theory of motivation is:
(a) O. H. Mowrer
(b) McClelland
(c) J. W. Atkinson
(d) A. H. Maslow
(e) None of the above
Answer: D

317. When progress towards a goal is blocked and underlying tension is unresolved, we speak of:
(a) Frustration
(b) Critical Period
(c) Goal
(d) Restriction
(e) None of the above
Answer: A

318. Survival needs activate the organism to:
(a) Provide for physiological deficits
(b) Seek pleasure
(c) Avoid pain
(d) Gain status and recognition
(e) None of the above
Answer: A

319. Motives can be:
(a) Inferred from behaviour
(b) Observed directly
(c) Used to explain behaviour
(d) Used to predict behaviour
(e) None of the above
Answer: A

320. A motivated behaviour is directed towards:
(a) Situation
(b) Object
(c) Goal
(d) Group
(e) None of the above
Answer: C

321. Needs, drives or motives:
(a) Can be directly observed
(b) Cannot be directly observed
(c) Are always dormant

(d) Are same
(e) None of the above
Answer: B

322. Gregariousness is a/an:
(a) Social motive
(d) Biological motive
(c) Psychological motive
(d) Personal motive
(e) Internal motive
Answer: A

323. Individual's life goal is:
(a) Social Motive
(b) Biological Motive
(c) Personal Motive
(d) An Instinct
(e) None of the above
Answer: C

324. When the motive has a biological or physiological basis, it is called a/an:
(a) Drive
(b) Incentive
(c) Imprinting
(d) Libido
(e) None of the above
Answer: A

325. Motives are never observed directly; but they are inferred from:
(a) Stimulus
(b) Conflict
(c) Tension
(d) Behaviour
(e) None of the above
Answer: D

326. The first stage of motivational cycle is:
(a) Drive state
(b) Instrumental behaviour
(c) Goal
(d) Frustration
(e) None of the above
Answer: A

327. In studying motivation, we attempt to answer:
(a) The broadest "why" question of behaviour
(b) The innate releasing mechanism
(c) Fixed-action pattern
(d) Displacement behaviour
(e) None of the above
Answer: A

328. The level of arousal is maintained by a structure in the brain stem called the:
(a) Pons
(b) Lymbic system
(c) Reticular activating system

(d) Cerebellum
(e) None of the above
Answer: C

329. Motivation can be understood as an interaction between:
(a) Arousal and Effort
(b) Vactor and Valence
(c) Life space and Approach gradient
(d) Approach gradient and avoidance gradient
(e) None of the above
Answer: A

330. Many years ago, an American Psychologist did a study in Orissa in which he found that achievement needs are higher in the business caste. What is his name?
(a) Lewis
(b) Mowerer
(c) Maslow
(d) Mc Clelland
(e) Lorenz
Answer: D

331. A desire to achieve success and to meet some inner standard of excellence is a good definition of the:
(a) Achievement Need (n ACH):
(b) Fixed-Action pattern
(c) Displacement behaviour
(d) Encephalization
(e) None of the above
Answer: A

332. The "need for success", "expectancy for success" and the "incentive value of success" are three motivational factors which determine the strength of:
(a) Social Motives
(b) Biological Motives
(c) Personal Motives
(d) Achievement Need
(e) None of the above
Answer: D

333. The need to achieve is jointly determined by:
(a) The expectation of success and the fear of failure
(b) The blocking of behaviour and fear of failure
(c) The drive stimulus and approach gradient
(d) The innate releasing mechanism and frustration
(e) None of the above
Answer: A

334. Social conformity can be described as a reverse:

(a) J—curve
(b) S—curve
(c) U—curve
(d) T—curve
(e) V—curve
Answer: A

335. F. H. Allport (1935) described social conformity as the:
(a) S—curve hypothesis
(b) V—curve hypothesis
(c) U—curve hypothesis
(d) J—curve hypothesis
(e) None of the above
Answer: D

336. As motivation is closely related to effort, the emotion is related to:
(a) Arousal
(b) Instinct
(c) Displacement behaviour
(d) Conflict
(e) None of the above
Answer: A

337. Fritz Heider, an Austrian psychologist, has given us a great deal of insight into:
(a) Imprinting
(b) Critical period
(c) Interpersonal relationships
(d) Coolidge Effect
(e) None of the above
Answer: C

338. A motive ethnologically means that
(a) Which moves
(b) Which distracts
(c) Which drives
(d) Which stimulates
(e) None of the above
Answer: A

339. Since motives activate the organism, they are also known as the:
(a) Outer dynamics
(b) Drive stimulus
(c) Inner dynamics
(d) Approach gradient
(e) Substitute behaviour
Answer: C

340. The second stage of the motivational cycle is called the:
(a) Goal
(b) Instrumental Behaviour
(c) Driving State
(d) Relief
(e) None of the above
Answer: B

341. Prolactin, a hormone from the anterior pituitary gland plays an important role in motivating:
(a) Maternal behaviour
(b) Imprinting
(c) Instinct
(d) Consummatory behaviour
(e) None of the above
Answer: A

342. Behaviour of the mentally ill persons is greatly influenced by their:
(a) Conscious motives
(b) Innate Releasing Mechanism
(c) Unconscious motives
(d) Fixed-action pattern
(e) Displacement behaviour
Answer: C

343. Generally we infer needs and desires from:
(a) Covert behaviour
(b) Approach gradient
(c) Drive stimulus
(d) Overt Behaviour
(e) None of the above
Answer: D

344. Physiologists use the term homeostasis to describe the body's tendency to maintain a balance or equilibrium among it's:
(a) External physiological status and environment
(b) Internal physiological status and the environment
(c) Displacement behaviour and encepha- lization
(d) Approach gradient and avoidance gradient
(e) None of the above
Answer: B

345. The relative strength of the drives of hunger, thirst and sex have been studied experimentally in the white rat by:
(a) Learning Method
(b) Obstruction Method
(c) Activity wheel
(d) The choice and Preference Method
(e) Questionnaire Method
Answer: B

346. The technique by which the strength of need is measured in terms of readiness with which a task is learned under different conditions of motivation is known as:
(a) Activity wheel
(b) Obstruction method

(c) The choice and Preference Method
(d) Learning Method
(e) None of the above
Answer: D

347. The technique for the measurement of needs by which the strength of a need is measured in terms of the magnitude of an obstacle or the number of times an obstacle of a given magnitude will be overcome in order to obtain a needed object is known as:
(a) Learning Method
(b) Obstruction method
(c) Activity wheel
(d) The choice and Preference Method
(e) None of the above
Answer: B

348. A tension within an organism which tends to organize the field of the organism with respect to certain incentives or goals and to incite activity directed towards their attainment is called:
(a) Need
(b) Imprinting
(c) Libido
(d) Valence
(e) Vector
Answer: A

349. An intraorganic activity or condition of tissue supplying stimulation for a particular type of behaviour is known as:
(a) Need
(b) Motive
(c) Drive
(d) Conflict
(e) Tension
Answer: C

350. Maslow viewed that motivated behaviour is:
(a) Need related
(b) A vector
(c) A valence
(d) An approach gradient
(e) Coolidge Effect
Answer: A